EXHIBIT A
WORK STATEMENT

INTRODUCTION

The Public Power Renewable Energy Action Team (PPREAT) is a broad, new collaboration of California municipal utilities, irrigation districts, potential community aggregators (including non-utility municipalities), and renewable energy developers and others aimed at utilizing renewable resources to help ensure the cost-effectiveness, reliability and resource diversity of California's electricity system. PPREAT, administered by the Center for Resource Solutions supports the public power system in California by facilitating the development of renewable-based electric generation projects that reduce risk and stabilize electric system costs in an environmentally sensitive way. The group works through a collective planning process to investigate the feasibility of and benefits to California's power system from a comprehensive resource-based generation portfolio that includes a significant proportion of renewable energy. Ultimately, PPREAT will develop long-range renewable power procurement strategies that can compete head-to-head on value with traditional utility power resources. PPREAT will achieve its goals through a combination of management and technical activities. In particular, by focusing on the advancement of renewable energy technology and science PPREAT will ensure the availability of cost-effective renewable energy supply in both the near and long-term.

PPREAT was formed in the Fall of 2000. Utility participants in the formation of PPREAT include those listed in the Table 1. PPREAT also maintains a group of strategic partners and technical advisors – listed in Table 2 – that are called upon to provide assistance to PPREAT members. The contractor, one of the founding organizations of PPREAT, is happy to submit this proposal to the Commission on behalf of PPREAT.

TABLE 1. PPREAT PARTICIPANTS

	Plumas-Sierra Rural Energy Cooperative
City of Anaheim	City of Vernon
Western Area Power Administration	Pasadena Water and Power Department
Los Angeles Department of Water & Power	Silicon Valley Power
Sacramento Municipal Utility District	Truckee-Donner Public Utility District
City of Redding	City of Lompoc
City of Riverside	Glendale Water and Power
Alameda Power & Telecom	City of Palo Alto
Lassen Municipal Utility District	City of San Francisco/Hetch Hetchy
Merced Irrigation District	Trinity Public Utility District

TABLE 2. PPREAT STRATEGIC PARTNERS

Sandia National Laboratory	U.S. DOE Golden Field Office
Lawrence Berkeley National Laboratory	U.S. Department of Agriculture, Rural Utility Service
National Renewable Energy Laboratory	U.S. DOE, Office of Power Technologies
U.S. DOE Seattle Regional Office	Center for Resource Solutions
Bonneville Power Administration	Pacific Northwest National Laboratory
Land and Water Fund of the Rockies	

PPREAT's research program encompasses all emphasis areas, matching information about resources and technological potential with superior technology and a commitment to implement the positive results obtained through this and related activities.

List of Program Goals and Objectives

At the highest level, the goal of PPREAT is to facilitate the more effective implementation of a portfolio approach to energy management. PPREAT's goal under this R&D program is to advance renewable energy science and technology in ways that allow PPREAT utilities, energy service providers (ESPs) and utility distribution companies (UDCs) to integrate renewable resources as a principal component of their resource portfolios. It is worth emphasizing that PPREAT utilities fully intend to take advantage of the technical and scientific advances made under this contract and implement a significant number of renewable energy projects based on those advances. PPREAT also believes that the results of its efforts will provide substantial and enduring benefits to the State's investor-owned utilities and their customers.

PIER Objectives

This program supports the PIER objectives of improving the energy cost/value and the reliability/quality of California's electricity by developing a coordinated set of advanced renewable energy technologies that together will help make renewables part of a more affordable diverse electricity system.

Technical and Economic Objectives

The specific technical and economic objectives of individual PPREAT projects, and their related performance metrics and baseline conditions, are detailed in the project work statements below. Rather than restating those details, here we focus on a broader array of program objectives (and associated performance metrics) that relate to the integrated and coordinated family of projects. PPREAT welcomes ongoing evaluations of its ability and progress towards achieving both these overarching objectives and the more detailed objectives laid out in the project work plans.

The specific projects are designed to achieve – in a coordinated fashion – PPREAT's overarching technical and economic objectives of:

1) Accelerating in the near term the cost effectiveness and value of using renewable energy as a significant component of a resource portfolio.
2) Advancing the development of cutting-edge renewable technologies to ensure the increasing availability of renewable options in the longer term.
3) Supporting the application of renewable energy sources in targeted, distributed generation applications to increase grid reliability, reduce transmission and distribution upgrade costs, meet peak demand and reduce transmission congestion, and satisfy customer needs.

These overarching objectives will, however, only be achieved if specific performance targets are met for renewable energy technologies over 5, 10 and 15-year time horizons. The current conditions facing renewable generation in the state and the overarching performance metrics that will be used to assess PPREAT's program success in meeting its objectives are summarized below. More detailed and project-specific performance metrics and baseline conditions can be found in the project work plans.

List of Projects by Emphasis Area

Emphasis Area 1: Assessing and Targeting Renewable Energy Development

Project 1.1 Feasibility of Interconnecting Pacific HVDC Intertie
Project 1.2 New Wind Site ID and Qualification
Project 1.3 New Geothermal Resource Assessment

Emphasis Area 2: Increasing Affordability of Existing Renewable Energy Facilities

Project 2.1 Upgrading Existing Geothermal Sites

Emphasis Area 3: Expanding Affordability and Diversity Using Renewable Distributed Generation

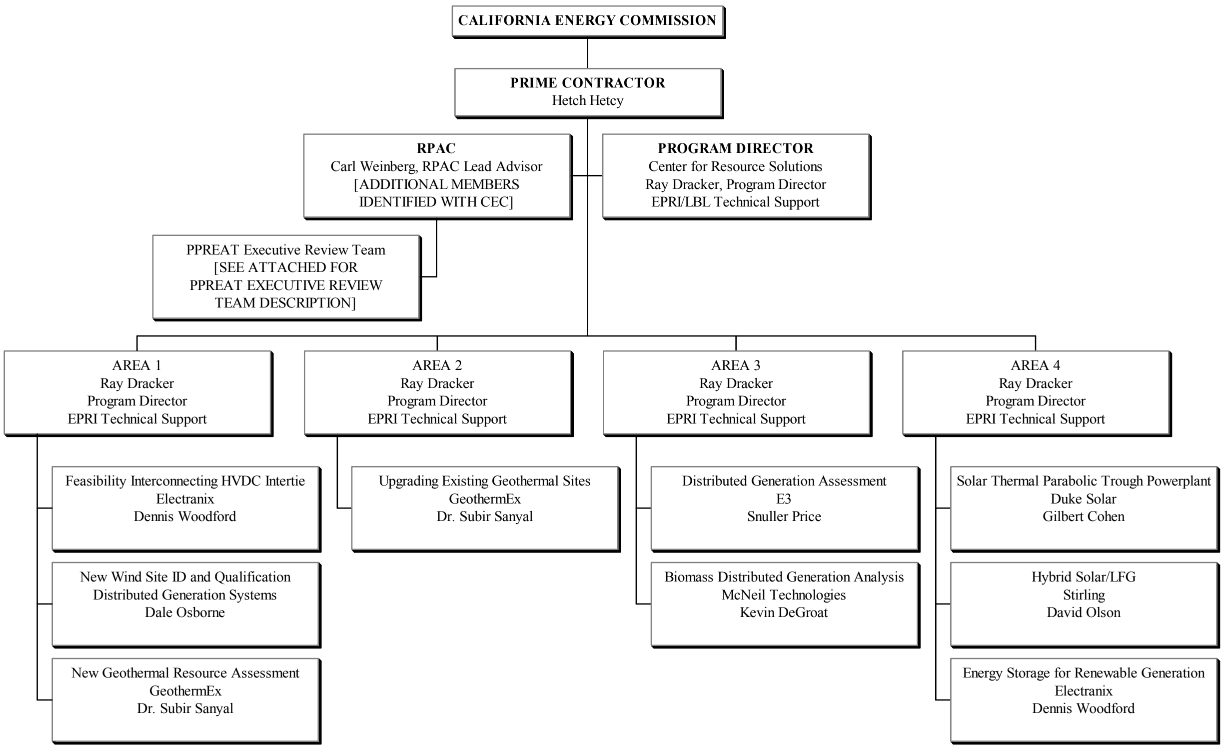
Project 3.1 Distributed Generation Assessment
Project 3.2 Biomass Project Distributed Generation Value Analysis

Emphasis Area 4: Developing Renewable Energy Technologies for Tomorrow's Electricity System

Project 4.1 Solar Thermal Parabolic Trough Powerplant
Project 4.2 Hybrid Biofuel/Natural Gas
Project 4.3 Energy Storage for Renewable Generation

GRAPHICAL SUMMARY OF PROGRAM ORGANIZATION

CALIFORNIA ENERGY COMMISSION RFP #500-00-506
ORGANIZATION CHART
PUBLIC POWER RENEWABLE ENERGY ACTION TEAM
HETCH HETCHY, PRIME CONTRACTOR



EMPHASIS AREA 0:
PROGRAM ADMINISTRATION

PROBLEM STATEMENT

The Program Administration element encompasses overall coordination and integration of the technical program elements for the many organizations participating in this program. It is imperative that a process is in place to effectively manage this program to achieve the program and project goals within allocated budget and schedule.

ADMINISTRATIVE GOALS

The Program Director has overall responsibility for managing the program to achieve the specified technical and economic performance goals and to ensure that research results meet guidelines for quality within budget and schedule. This will require coordinating R&D efforts between the technical program elements. The coordination shall include overseeing assessment studies, tracking R&D progress and deliverables, ensuring the quality of RD&D results, identifying and facilitating program linkages between elements, implementing mechanisms to revisit the program's research direction and focus as research results are achieved, ensuring connection with the market and linkage to utility deployment programs, and establishing systems for reliable internal and external communications throughout the contract period.

PROJECT LIST

This program element's work scope involves the following administrative projects:

Project 0.1 Kick-Off Meeting
Project 0.2 Program Start-up Activities
Project 0.3 Program Meetings
Project 0.4 Annual Technical Briefings
Project 0.5 Progress Reports
Project 0.6 Final Report
Project 0.7 Final Meeting
Project 0.8 Project-Specific Administrative Tasks

This work statement includes objectives, contractor activities, task deliverables, key personnel and key subcontractors for each of the projects listed above. The deliverables are defined to the extent possible, but are subject to change based on recommendations from the Project Director and the approval of the Commission Contract Manager.

The Contractor has assigned the program management responsibilities to the Center for Resource Solutions, a Key Subcontractor. Unless other wise noted, there are no Key Personnel (contractor's employees) for individual projects or tasks. Key Personnel and Key Subcontractors are listed at the end of each project.

PROJECT 0.1: Program Kick-Off Meeting
The objectives of this project are to review the Commission's expectations for this contract work, to coordinate activities between multiple PIER Renewables contracts, and to establish an initial schedule for future contract meetings.

The Contractor shall attend a kick-off meeting with the Commission Contract Manager and Contract Officer to review the Commission's expectations for accomplishing tasks described in the work statement and the requirements in the contract terms and conditions.

This kick-off meeting will also accomplish the following contract coordination efforts between the Commission Contract Manager, the Program Director and the Program Element Leads:

- Establish the schedules for the monthly reports.
- Establish an initial schedule for the critical program reviews.
- Identify software requirements for all software products developed or enhanced in this contract.
- Concur on the uses of the program management web site.
- Discuss project-specific administrative tasks and the schedule for the individual kick-off meetings.
- Discuss a plan to coordinate the PIER programmatic contracts. At a minimum, this coordination shall include producing and sharing a contact list, web site links, and research bibliographies. The plan shall also include initial schedules and protocols for future research coordination and Program Advisory Committee meetings.

The Commission Contract Manager shall designate the date and location of this meeting. The Commission Contract Manager will be responsible for recording the decisions, agreements and schedules determined at this meeting. The Program Director is responsible for reviewing these written meeting minutes and providing a written letter to the Commission Contract Manager summarizing the agreements and containing all appropriate planning information.

Deliverables:
- Attend Kick-off meeting
- Written documentation of meeting agreements and all pertinent information.
- Written initial schedule for future contract meetings.

Key Subcontractor:
Ray Dracker/CRS/Technical Support will be responsible for this task.

PROJECT 0.2: Program Start-Up Activities

Task 0.2.1: Public Presentation
The objective of this task is to provide PIER stakeholders, interested parties and the general public an opportunity to be introduced to the research, development and demonstration work that will be undertaken in this contract.

The Contractor shall prepare an outline of the goals and objectives of the program and make a 60-minute presentation at a half-day public presentation. This meeting will introduce all three programmatic PIER contracts to the meeting attendees. The Commission Contract Manager shall designate the date, time and location of this meeting. The Commission shall designate the other participants in the public meeting. The Commission is responsible for publicizing the meeting.

Deliverables:
- A prepared 60-minute presentation (electronic copy to Contract Manager)

Task 0.2.2: Program Software Standardization

There are three objectives in this task. 1) Unify the file formats of electronic data and documents provided to the Commission as contract deliverables. 2) Establish the computer platforms, operating systems and software that will be required to review and approve all software deliverables, and 3) Establish and maintain a program management web site.

The Contractor shall deliver documents to the Commission Contract Manager in the following formats:

- Data sets shall be in Microsoft (MS) Access or MS Excel file format.
- PC-based text documents shall be in MS Word file format.
- Documents intended for public distribution shall be in PDF file format.
- Project management documents shall be in MS Project file format.
- Presentation documents shall be in MS Power-Point format.

Exceptions to the above file formats must be submitted in a Notification Letter and pre-approved in writing by the Commission Contract Manager.

Computer platforms, operating systems and software requirements for all software deliverables shall be listed in a Notification Letter and approved by the Commission Contract Manager at least 90 days before the software is scheduled to be reviewed by the Commission.

The Contractor shall establish a program management web site. This shall be done in consultation with the Commission Contract Manager. A portion of the site shall be password protected.

Deliverables:
- Notification Letter(s) for File Formats.
- Notification Letter(s) for computer platforms, operating systems and software requirements.
- Program Management Web Site.

Task 0.2.3: Finalize the Renewables Project Advisory Committee
The objective of this task is to create an advisory committee for this program. The purpose of this Renewables Project Advisory Committee (RPAC) will be to:

- Provide strategic guidance to the Program Management Team (consisting of the program director, the leads of each program element, and the Commission Contract Manager).
- Review current and future deliverables to evaluate functionality of the deliverables. Provide specific suggestions/recommendations for needed adjustments, refinements, or enhancement of the deliverables.

- Provide guidance in research direction. The guidance should include, but not be limited to, scope of research; research methodologies; timing; coordination with other research, etc. The guidance may be based on:
- technical area expertise
- knowledge of market applications
- linkages between the programmatic contract work and other past, present or future research (both public and private sector) they are aware of in a particular area
- Evaluate tangible benefits to California and provide recommendations, as needed, to enhance tangible benefits.
- Provide recommendations regarding information dissemination, market pathways or commercialization strategies relevant to the research products.

The RPAC should be composed of 8-12 diverse professionals. This RPAC size shall be a target that the Contractor strives to achieve. This number can vary depending on potential interest and time availability, however 8 should be considered a practical minimum. The RPAC shall be composed of qualified professionals spanning the following disciplines:

- Researchers knowledgeable regarding renewable energy technologies in the listed projects
- Entities Who Would Use the Developed Technologies, Products or Services at the Project Level
    - Renewable Energy Project Developers (Engineers/Architects)
    - Renewable Energy Project Owners
    - Renewable Energy Project Operators
- Entities Who Would Use the Developed Technologies, Products or Services at the Systems Level
    - Electricity Suppliers (as defined in this solicitation)
- Renewable Energy Product Developers
    - Renewable Energy Equipment and Control Manufacturers
    - Other product developers relevant to individual emphasis areas and projects in the program
- Public Sector Decision Makers
- DOE Renewable Energy Research Managers
- Public Interest Environmental Groups

The Contractor shall recruit RPAC members and ensure that each individual understands the member obligations described above, as well as the meeting schedule outlined in Task 0.3.2. The Contractor may propose subsets of the RPAC to contribute to specific technical elements, thereby eliminating the need for every RPAC member to participate in every teleconference and meeting. This proposed RPAC organization shall be pre-approved in writing by the Commission Contract Manager.

Deliverables:
- A list of RPAC members that includes name, qualifications, company, physical and electronic address, and phone number.
- A brief written explanation of the RPAC organization. This document will include a delineation of which RPAC members will participate in each specific technical contract element.
- Letters of acceptance, or other comparable documentation of commitment, for each RPAC member.

Task 0.2.4: Document Matching Funds
The objective of this task is to document the match funds for this contract.

- The Contractor need not resubmit match fund documentation if it was provided in the Contractor's proposal and the information submitted is still valid. The Contractor, however, shall assist the Commission Contract Manager to locate this proposal information, upon request.

- In the event match fund sources change during the contract term, Contractor shall immediately notify the Commission Contract Manager for approval.

Documentation of match fund commitments shall be received, reviewed and approved in writing by the Commission Contract Manager before: 1) any PIER funds under this contract are disbursed; and 2) PIER-funded work on technical tasks may begin.

The Contractor shall provide the following information about the match funding to be used to conduct this program:

1. Amount and source of each *cash* match funding, including a contact name, address and telephone number.

2. Description, documented market or book value, and source of each *in-kind* contribution, including a contact name, address and telephone number.

   If the in-kind contribution is equipment or other tangible or real property, Contractor shall identify its owner and provide a contact name, address and telephone number, and the address where the property is located.

3. Written commitment from each source of cash match funding or in-kind contributions that these funds or contributions have been secured or will be secured prior to the date(s) when the funds or in-kind contributions are required for program expenditures.

In the event the Contractor has not provided the written match fund commitments for this program by three months after the contract approval date, the Commission may, at its option and in its unfettered discretion, terminate this agreement by advising Contractor in writing that the contract will be terminated in thirty (30) calendar days.

Deliverables:
- Written documentation of matching fund agreements or written letter declaring that there have been no changes in match fund agreements.
- Documentation of changes as they occur.

Key Subcontractor:
Ray Dracker/CRS/Technical Support will be responsible for this task.

Task 0.2.5 Identify and Obtain Required Permits
The goal of this task is to list all permits required for work completed under this contract.

The Contractor shall:
- Provide the following information about permits required for this contract:
  - Type of permit
  - Name, address and telephone number of the permitting jurisdictions or lead agencies
  - Schedule the Contractor will follow in applying for and obtaining these permits
  - A copy of each permit.

- Submit this information to the Commission Contract Manager at the kick-off meeting. The schedule of obtaining permits will be discussed at the kick-off meeting, and a timetable for submitting updated lists of permits will be developed. In all cases, permits must be identified in writing and obtained before any costs related to the use of the permit(s) are incurred for which PIER reimbursement will be requested under this contract.

- If no permits are required, the Contractor shall state this finding in writing to the Commission Contract Manager.

Deliverables:
- List of all permits required or a statement that no permits are required.
- Updated list of permits as they change during the contract term.
- A copy of each permit.

Key Subcontractor:
Ray Dracker/CRS/Technical support will be responsible for this task.

PROJECT 0.3: Program Meetings

Task 0.3.1: Critical Program Review Meetings
The objective of this task is for the Commission to discuss with the Contractor the status of the program and its progress toward achieving its goals and objectives.

Critical program reviews are meetings between the Contractor, the Commission Contract Manager and other individuals selected by the Commission Contract Manager to provide objective, technical support to the Commission.

Meeting participants may include PIER Team Lead, Contracts Officer, Commission Technical Staff and Management. These meetings may take place at the Energy Commission offices in Sacramento, or at another, reasonable location determined by the Commission Contract Manager.

Prior to this critical program review meeting, the Contractor shall provide the task deliverable(s) to the Commission Contract Manager sufficiently in advance to allow the Contract Manager's review of the deliverable document(s) before the review meeting. If not already defined in the Work Statement, the Commission Contract Manager shall specify the contents of the deliverable document(s).

At the critical program review meeting, the Contractor shall present the required administrative and technical information, and participate in a discussion about all the program elements with the Commission Contract Manager and other meeting attendees.

Following the critical program review meeting, the Commission will determine whether the Contractor is complying satisfactorily with the Work Statement and whether the program elements are demonstrating sufficient progress toward their goals and objectives to warrant continued PIER financial support for each element.

As an outcome of each Critical Program Review, the Commission Contract Manager will provide a written response within 10 working days to the Contractor indicating his or her conclusions about the program to date. The written response may include a requirement for the Contractor to revise one or more deliverables that were included in the Critical Program Review. After each review, the Commission Contract Manager may reassess and reallocate the tasks, schedule, deliverables and budget for the remainder of the work including not proceeding with one or more tasks, or to stop work.

If the Commission Contract Manager concludes that satisfactory progress is not being made, this conclusion will be referred to the Commission's Research, Development and Demonstration Policy Committee for its concurrence.

Deliverables:

- Recommended critical program review schedule deliverable for kickoff meeting.
- Critical program review deliverables identified in this work statement or as specified by the Commission Contract Manager.
- Updated schedule for critical program reviews, provided as necessary.

Task 0.3.2: RPAC Meetings

The objective of this task is for the RPAC to provide strategic guidance to this program by participating in quarterly meetings or teleconferences.

The Contractor shall:

- Organize and lead RPAC meetings with the Program Management Team on the following schedule:
- Quarterly reviews with the RPAC, 1 or 2 of which each year will be meetings at a location to be determined in consultation with the Commission Contract Manager, and the remainder to be teleconferences.
- Exceptions to the above schedule must be pre-approved in writing by the Commission Contract Manager.
- Summarize each RPAC meeting or teleconference in writing.

Deliverables:

- Suggested RPAC meeting schedule.
- Draft RPAC meeting agenda(s) with back-up materials for agenda items.
- Final RPAC meeting agenda(s) with back-up materials for agenda items.
- Written meeting summaries.

Key Subcontractor:

Ray Dracker/CRS/Technical support will be responsible for this task.

PROJECT 0.4: Annual Technical Briefings
The objective of this project is for the contractor to share the progress and results of the research conducted in the program with state and national research communities.

The Contractor shall present at least one technical briefing on the research being conducted in this program during each year of this contract. The Contractor shall provide a written summary of the technical briefing that includes but is not limited to the event and the date, a copy of the presentation, any handouts that were provided the attendees, the approximate number of attendees, and the results of the briefing (e.g., research products incorporated into a broader scope of work by others).

***Deliverables*:**
- A written summary of each technical briefing given by the Contractor on the subject of research conducted within the program.

Key Subcontractor:
Ray Dracker/CRS/Technical Support will be responsible for this task.

PROJECT 0.5: Reporting

All public reports shall be delivered to:

Accounting Office, MS-2
California Energy Commission
1516 9th Street, 1st Floor
Sacramento, CA 95814

All confidential reports shall be sealed and marked "Confidential Deliverable" and submitted to:

Judith Efhan
Contracts Office, MS-18
California Energy Commission
1516 9th Street, First Floor
Sacramento, CA 95814

Task 0.5.1: Monthly Reports
The objective of this task is to periodically verify that satisfactory and continued progress is being made towards achieving the research objectives of this program.

The Contractor shall submit a Monthly Progress Report to the Commission Contract Manager, starting one month after contract execution and shall continue each following month until the Commission Contract Manager has accepted the Final Report. Attachment 1 provides the format and content requirements for these reports. This format and process shall be used for the monthly reports for the program and for each project.

The Contractor shall maintain a Monthly Highlights Section in the password-protected portion of the Program Management Web Site. The Monthly Highlights Section shall include interim research results (e.g., test data, product mock-ups, field site descriptions, preliminary analyses, draft reports, photographs) necessary to allow the Commission Contract Manager to review contract progress and gauge the quality of research results. They shall also include evidence of software testing as appropriate for software developed or enhanced in this contract. The software test methods shall be discussed and agreed to during the contract kickoff meeting. The Commission Contract Manager will not accept final deliverables nor approve invoices for deliverables without prior review and approval of progress reports and draft deliverables.

***Deliverables*:**
- Written Monthly Progress Reports, for the Program and for each Project, due within 30 days of month's end.
- Monthly Highlights due within 30 days of month's end.

Task 0.5.2 Year End Reports
The objective of this task is to annually verify that the Commission is receiving the research products expected from this contract. A further objective of this activity is to revise Year 2 & 3 work, if necessary, to incorporate the recommendations of the RPAC and of the Commission that will result from the project deliverables and critical program reviews. Attachment 2: Year-end Report Format provides a suggested framework for this report.

The Contractor shall:

- Prepare a Year-End Report for each of the first two years of this contract, describing the original purpose, approach and results of the year's work. This shall include a summary of deviations and corrections to the original research plans. This report shall also include draft research plans with deliverables for the following contract year. These research plans shall incorporate changes in the following year's work plans with deliverables to reflect the results of RPAC reviews and the Commission Critical Program and Project Review(s) conducted in the previous year. Year End Reports shall also include updates to the baseline conditions, projected outcomes and performance metrics for each program element.

- Submit the draft reports to the Commission Contract Manager for review and comment. The Commission Contract Manager will present the draft reports to the R&D Committee for their approval. Work may not proceed in Years Two and Three until Committee approval has been obtained.

- Once agreement on the draft reports has been reached, the final reports shall be submitted to the Commission Contract Manager for written approval, which shall be provided within 5 working days of receipt of the final reports.

- Submit an invoice for the previous year's retention along with the final year end reports.

***Deliverables*:**
- Draft Year-end Reports for the Program and for each Project.
- Final Year-end Reports for the Program and for each Project due within 30 days of year-end.
- Retention invoice.

Key Subcontractor:
Ray Dracker/CRS/Technical support will be responsible for this task.

Task 0.5.3 Technical Deliverables

The Contractor shall use Attachment 3 as guidance for preparing the technical deliverables in this contract.

***Deliverables*:**
- As required by each project

PROJECT 0.6: Final Report
The Final Report shall be a public document. If the Contractor has obtained confidential status from the Commission and will be preparing a confidential version of the Final Report as well, the Contractor shall perform the following tasks for both the public and confidential versions of the Final report. Attachment 4 provides the format and content requirements. This format and process shall be used for the final reports for the program and for each project.

For each project, the final report will be prepared at the conclusion of the project. The project specific final reports shall fully document the work performed in each project. They shall address the degree to which the project's goals and objectives were achieved, problems encountered, lessons learned and recommendations for future work.

For the program, this report will be prepared at the end of the contract. The program final report shall address the degree to which the collection of projects achieved the goals and objectives of the program, problems encountered, lessons learned and recommendations for future work.

Task 0.6.1 Final Report Outline

The Contractor shall:
- Prepare an outline of the Final Report describing the original purpose, approach and results of the project.
- Submit the final report outline to the Commission Contract Manager for review and acceptance. Once agreement on the outline has been reached, it shall be submitted to the Commission Contract Manager within 5 working days. The Commission Contract Manager shall provide written acceptance within 5 working days of receipt.

Deliverables:
- Final Report Outline

Task 0.6.2 Draft Final Report

The Contractor shall:
- Prepare the Draft Final Report for the project. The format of the report shall follow the approved outline.
- Submit the draft final report to the Commission Contract Manager for review and comment. The Commission Contract Manager will provide comments within 20 working days of receipt. If the Commission Contract Manager takes reasonable issue with the format or thoroughness of the draft Final Report, the Contractor and the Commission Contract Manager shall in good faith discuss such issues and the Contractor shall take actions to address the Commission Contract Manager's concerns. Once agreement on the draft final report has been reached, the Commission Contract Manager shall provide written acceptance within 5 working days.

Deliverables:
- Draft Final Report

Task 0.6.3 Final Report

The Contractor shall:
Submit the final report within 10 working days of receipt of the acceptance letter. The Contractor shall submit two unbound copies and one electronic copy of the Final Report to the Commission Contract Manager.

Comment: what about electronic versions. What about our editing process? We could put these requirements into the Ts and Cs?

Deliverables:
- Final Report (two unbound copies and one electronic copy for each final report)

Comment: what about electronic versions. What about our editing process? We could put these requirements into the Ts and Cs?

Key Subcontractor:
Ray Dracker/CRS/Technical support will be responsible for this task.

PROJECT 0.7: Final Meeting

A final meeting for contract closeout will be attended by, at a minimum, the Contractor and the Commission Contract Manager. The technical and administrative aspects of contract closeout will be discussed at the meeting, which may be two separate meetings at the discretion of the Commission Contract Manager.

The technical portion of the meeting shall present findings, conclusions, and recommended next steps (if any) for the project. The Commission Contract Manager will determine the appropriate meeting participants.

The administrative portion of the meeting shall be a discussion with the Commission Contract Manager and the Contracts Officer about the following contract closeout items:

- What to do with any state-owned equipment (Options)
- Need to file UCC-1 form re: Commission's interest in patented technology
- Commission's request for specific "generated" data (not already provided in contract deliverables)
- Need to document Contractor's disclosure of "subject inventions" developed under the contract
- "Surviving" contract provisions, such as repayment provisions
- Final invoicing and release of retention

Deliverables:
- Meeting participation
- Written documentation of meeting agreements and all pertinent information.

Key Subcontractor:
Ray Dracker/CRS/Technical Support will be responsible for this task.

PROJECT 0.8: Project-Specific Administrative Tasks

For each project:

The Contractor shall:

1. Establish the accounting and project tracking system. The project tracking system shall be compatible with the Commission's software. Work with the Commission Contract Manager to develop all necessary aspects of the tracking system, including Gantt charts.
2. Work with the Commission Contract Manager and the subcontractors to fine-tune the work statement, if needed. The process shall include a review and comment process and final signoff by the Commission Contract Manager.
3. Obtain from the major subcontractors all necessary financial information, including documentation of rates and fees, equipment and travel and identify pre-existing intellectual property and confidential deliverables. Discuss these with the Commission Contract Manager to determine how to include them in the contract.
4. Finalize the budget and schedule in accordance with the modified work statement (if applicable). Work with the subcontractors and the Commission Contract Manager to develop the budgets and prepare them

for use in subcontracts. The schedule shall include Critical Project Review(s) using the pattern for Critical Program Reviews described in Task 0.3.1.

5. Establish requirements and procedures for monthly, year-end and final reports and for technical deliverables. All subcontractors shall submit monthly reports, using the format in Attachment 1, which shall be compiled into a monthly report for submission to the Commission. The same is true for the year-end reports, using the format in Attachment 2. Final reports shall be prepared as each project is completed and shall follow the format in Attachment 4. Technical deliverables shall conform to Attachment 3.
6. Develop research-project subcontracts that meet all of the Commission's requirements.
7. For projects without subcontractors, issue RFPs and obtain subcontractors.
8. Prepare, assemble, obtain complete approval for and execute all agreements with subcontractors. If needed, the Contractor will execute confidentiality agreements with the subcontractors. The Contractor shall be responsible for preparing the subcontracts and ensuring their proper execution.
9. Obtain from the subcontractors the required information on permits in accordance with 0.2.5.
10. Prepare a list of Critical Project Reviews for each project. The list shall identify opportunities to coordinate the reviews among the projects, when schedules and milestones can be coordinated. This list shall be submitted to the Commission Contract Manager within 90 days after the start of the program.
11. Conduct kickoff meetings for projects as necessary. The Contractor shall organize all aspects of the kickoff meetings, coordinating times and locations with the Commission Contract Manager. The Contractor shall keep minutes for each meeting and deliver copies of the minutes to the Commission Contract Manager.
12. Provide project management support to each project as necessary

Deliverables:

- Fully developed accounting and project tracking systems.
- Modified work statements (if needed).
- Modified budgets and schedules (if needed).
- A list of critical project reviews.
- A schedule of reporting requirements for each project.
- Fully executed subcontracts.
- Issued RFPs (as needed) and completed contracts with subcontractors not listed in this proposal.
- Permit information as required.
- Completed kickoff meetings with deliverables provided to the Commission.

Key Subcontractor:

Ray Dracker/CRS/Technical Support will be responsible for this task.

EMPHASIS AREA 1:
ASSESSING AND TARGETING RENEWABLE ELECTRICITY DEVELOPMENT

PROBLEM STATEMENT

Renewable energy may be the most cost-effective option for providing today's electricity system needs while also adding important portfolio diversity. PPREAT work in Area One will identify cost-effective options for bringing new renewable resources into California's resource portfolio.

▪**Key Barriers**

Today's portfolio and power acquisition planners lack guidance on the real-world options for deploying renewable resources to meet current electricity needs. PPREAT efforts in this area will address that lack of information through a series of linked analysis activities.

▪**Advancement of Science or Technology**

Implementing cutting-edge resource analysis and transmission modeling tools, PPREAT activities in this area will document the feasibility of deploying renewable resources on a utility-scale, grid-connected level.

EMPHASIS AREA GOALS AND PERFORMANCE OBJECTIVES

Identifying new options for deploying renewable resources to meet California's electricity needs. Evaluate relative cost-effectiveness of new resource options. For supplementary detail on area goals and performance objectives, see each Project Work Statement (below)

PROJECT LIST

This emphasis area's work scope involves the following technical projects:

Project 1.1 Feasibility of Interconnecting to the Pacific HVDC Intertie (Electranix)

The high voltage DC intertie near the California-Nevada border may present opportunities to bring several thousand megawatts of new geothermal and wind resources into California. PPREAT will explore the technical and financial aspects of interconnection to the Pacific HVDC intertie to bring new wind and geothermal resources to the California market.

Project 1.2 New Wind Site Identification and Qualification (Distributed Generation Systems)

PPREAT will identify the potential for the development of wind resources that would benefit from the HVDC intertie and synergies between the development of these renewable resources and planned or potential natural gas generation near the HVDC intertie. Sites not in proximity to the HVDC line will also be explored. PPREAT will also develop an evaluation of potential synergies between wind resource locations and existing planned or potential natural gas plant developments and storage opportunities associated with Western Area Power Administration's (WAPA) Central Valley Project. This assessment of wind resources will build on existing resource maps.

Project 1.3 New Geothermal Site Identification and Qualification (Geothermex)

PPREAT will identify the potential for the development of geothermal resources that would benefit from the HVDC intertie and synergies between the development of these renewable resources and planned or potential natural gas generation near the HVDC intertie. PPREAT will also develop a detailed statewide assessment of geothermal resources and an evaluation of potential synergies between geothermal resource locations and existing planned or potential natural gas plant developments. The resource assessment will build on existing resource maps.

PROJECT 1.1: FEASIBILITY OF INTERCONNECTING TO THE PACIFIC HVDC INTERTIE

Problem Statement

Areas with significant wind, geothermal, hydro and solar energy potential along the California-Nevada border are currently untapped sources of significant renewable energy resources. The Pacific HVDC Intertie passes directly through these areas (it is an important energy source for southern California), but existing technologies to tap into HVDC systems have been complex and prohibitively expensive compared to the benefit of developing these new energy sources.

Considering current (and forecasted) energy costs and volatility, these "green" energy resources may now be viable, providing a suitable interconnection is feasible. This project will assess the use of modern technologies to bring energy from these untapped resources to the California market firstly via an interconnection with the Pacific HVDC Intertie, and secondly, via an interconnection to available AC transmission in the area, and with recommendations for necessary upgrades of that transmission.

If the interconnection is feasible, the economic benefits include:
- A new source of cost-effective energy to feed the Southern California markets.
- New opportunities for electricity suppliers in Northern California.
- Stabilization of energy prices due to additional generation.

The environmental benefits of a new interconnection include:
- New access to "green" energy sources such as wind power, photovoltaic (solar), hydro and geothermal.
- Lower demand for non-environmentally friendly energy.

A key aspect of this work is to ensure that any proposed interconnection to the existing HVDC system does not degrade its operation, recognizing its critical status for supply of energy to Southern California.

In order to ensure that the recommendations are realistic, input and comment will be sought, as appropriate, from the transmission owners in the region on the existing limitations and ways to incorporate 500 to 2000 MW of transmission from renewable energy sources near the California – Nevada border.

Prior Research

The technical challenge to this project is to determine how an effective interconnection to the Pacific HVDC Intertie can be achieved. This requires a multi-terminal DC configuration for the HVDC Intertie. Although in its present configuration, the HVDC Intertie has an effective multi-terminal configuration at its sending and receiving end converter stations, the addition of one or more interconnections mid-line poses a significant technical challenge.

Use of a HVDC transmission line in multi-terminal configuration is not a new consideration but costs can be a significant factor. Now that energy costs and the demand for "green" energy are higher, a HVDC interconnection becomes more appealing.

Multi-terminal HVDC technology is mature. HVDC transmission systems in Hydro Quebec and Nelson River in Manitoba, Canada are capable of paralleling and multi-terminal operation. High additional costs during the initial design make the use of multi-terminal HVDC technology economical only for very large converter stations. Classical multi-terminal HVDC inverter technology also presents the undesirable possibility that a fault or commutation failure at one inverter (say a small tapping point) can cause the entire HVDC system to fail and to delay recovery to normal operation.

An aspect of this project is to examine the use of Voltage Sourced Converters (VSC), which use gate turn off (GTO) and integrated gate bipolar transistors (IGBT) switching devices instead of conventional thyristors. VSC technologies can avoid commutation failures and could thus make it feasible to add small to medium sized taps on the HVDC system without affecting performance of the existing link. Use of Voltage Sourced Converters in this manner is not without its difficulties. Use of modern power system simulation and study tools will be applied to investigate configurations and feasibility for various interconnection options, using VSC and conventional thyristor technologies. The use of Voltage Sourced Converters for a multi-terminal interconnection to an existing HVDC transmission line will be a unique activity of this contract. If shown to be acceptable and feasible, it will open up the way for further applications for interconnection to HVDCV transmission lines around the world.

Direct current electric power transmission using Voltage Sourced Converters has been studied previously by members of this HVDC team. Project 2000 [EPRI TR-11182] spearheaded by Western Area Power Administration (WAPA), Bonneville Power Administration (BPA) and EPRI along with equipment suppliers, other utilities and research institutes started a series of investigative projects in 1995 based on study results from the Department of Energy [ORNL/Sub/95-SR893/1]. This work increased the confidence in use of VSC technology for DC power transmission applications, and today the first VSC transmission in the US has been commissioned at Eagle Pass, Texas as an international interconnection to Mexico.

The use of VSC transmission to bring electric power from large wind farm installations is a project Electranix Corporation is undertaking for Eltra, the West Denmark Transmission Operator. This work is investigating the feasibility of VSC for wind farm application and will provide a good reference and background for this project to interconnect to the Pacific HVDC Intertie. The project in Denmark will expand later this year to investigate increasing the efficiency of wind farms through energy storage.

The HVDC Team is well versed with the operation and control of the Pacific HVDC Intertie. They are also conversant with voltage sourced converter technology and transmission requirements for large wind farms.

Baseline Conditions

For this project to be considered a success, economic effectiveness must be complimented with maintained reliability of the Pacific HVDC Intertie, and overall minimum impact on the environment. More specifically, the following baseline conditions must apply:

- The reliability of the existing Pacific HVDC Intertie cannot be degraded. Because of the strategic nature of the Pacific HVDC Intertie to California, its reliability must in no way be compromised by an interconnection accessing local renewable energy sources.
- The interconnection and cost of this new renewable energy must be cost effective when compared against similar sources of energy. Determination of cost effectiveness will require full exploration of cost benefits that might be allocated to transmission for the renewable resources.
- The project must be environmentally friendly. In addition to making it possible for renewable energy sources to be developed in relatively remote locations, the transmission of this energy to the California load must be environmentally acceptable.
- Consideration for fast tracking transmission capacity for the renewable developments is a basic consideration.
- Various levels of transmission power capability will be anticipated within the range up to 2000 MW.

Project Goals

If this feasibility study is successful and the interconnection and renewable energy sources were developed, the following benefits will arise:

- A large source of renewable energy will become available for the California market, and because of the nature of this energy and its location, will add to the diversity of energy sources available to the State.
- A corresponding amount of less environmentally friendly energy will be displaced.
- A potential to stabilize energy prices in California due to the availability of renewable energy resources. Non-volatile energy pricing may be possible from the proposed renewable energy sources, with a stabilizing effect on overall electric energy pricing in California.

The program will provide a good technical assessment on the most suitable electric power transmission for the renewable energy resources identified for future development in the California-Nevada border regions. Permits for construction of overhead electric transmission lines are not obtained easily, and if there is any way possible to interconnect to the Pacific HVDC Intertie instead, this lengthy process may be significantly reduced.

Interconnection to an HVDC transmission line is a very technically complex thing to do and cannot be attempted without a significant amount of study and investigation. This project if successfully completed will show the way that this can be achieved. The economic viability will also be determined for the various transmission options and recommendations for future developments will be made. Such recommendations cannot be forthcoming at this stage unless this project is completed.

A realistic schedule of development over the next 15 years is as follows:

Year 1 to 3: Feasibility assessment as a result of this contract.

Year 4 to 5: Assembling of owners, approval from the appropriate California Independent System Operator, use of feasibility assessment to secure investment and funding, initiation of environmental impact study, initiation of permitting process, selection of project engineering consultant and commencement of the transmission planning study required for the specification of equipment.

It is possible that some capacity for transmitting energy from renewable energy sources near the California – Nevada border is possible with minimum permitting and expense. If such is identified in the report, this option could be pursued and be operating within this 5 year time frame.

Year 6 to 7: With permitting in place and essential studies undertaken, prepare specifications for main equipment and transmission specifications, open up the bidding process, select equipment suppliers, construction of transmission and substations.

Year 8 to 10: Commissioning of new transmission facilities and commencement of commercial operation.

Year 11 to 15: Commercial operation.

Project Objectives

1. Determine costs to interconnect a combination of wind and geothermal generation resources to the Pacific HVDC Intertie at single and multiple points near the Nevada-California border in amounts of 500, 1000, 1500, and 2000 MW.
2. Determine the available transfer capacity and technical feasibility of any potential AC transmission interconnection points and options that should be considered as an alternative strategy to interconnection into the Pacific HVDC Intertie.
3. Determine the optimal interconnection point(s) based on a technical analysis of available geothermal and wind resources near the California-Nevada border.
4. Determine the relative costs and advantages of developing a standalone AC collector grid for these renewable energy resources versus using the existing AC collector grid.

Performance Metrics

The following performance indices can be used to determine the effectiveness of the proposed interconnection:
- How much new renewable energy generation can be transmitted to customers in Northern California (where the need is greatest) and to Southern California?

- What is the expected return on investment for the recommended transmission option? This will be a main indicator of the project feasibility.
- What percentage of the Pacific HVDC Intertie energy capacity is utilized on a yearly basis? The amount of power and energy that is available to be delivered to Southern California through the Pacific HVDC Intertie will determine the capacity of the renewable resources that can be used, thus impacting the economic effectiveness of the project.
- What environmental impact does the new interconnection have? Although an environmental impact study is not included in this contract, the minimization of new transmission facilities is one measure of environmental impact. The less new transmission, the less environmental impact.
- Added energy from the development of renewable resources will increase the reliability of energy supply to the California power system.
- Benefits to investor owned utilities may be possible if it is evident that investment opportunities are possible with the development of the renewable energy sources and the associated transmission.
- How much renewable energy can be fast-tracked.

Project Work Plans

Task List:

Task 1.1.1:	Pre-feasibility Assessment of DC and AC Transmission Options.
Task 1.1.2:	Investigate Feasibility for Interconnecting to the Pacific HVDC Intertie
Task 1.1.3:	Investigate Feasibility of Use of AC Transmission
Task 1.1.4:	Determine Optimum Interconnection Location(s)
Task 1.1.5:	Investigate AC Collector Grid Configurations and Options
Task 1.1.6:	Study System Operational Performance
Task 1.1.7:	Costing and Economic Analysis of the Interconnection
Task 1.1.8:	Final Project Report

Task 1.1.1: Pre-feasibility Assessment of DC and AC Transmission Options
The objective of this task is a pre-feasibility exercise to develop possible options for interconnections both to the Pacific HVDC Intertie and for AC transmission possibilities.

The Contractor shall:

- Identify possible options for interconnections both to the Pacific HVDC Intertie and for AC transmission possibilities. These options will be developed based on the best engineering experience of the project team in DC and AC transmission and their understanding of the electric power system.

- Conduct a preliminary economic analysis on the options identified above to determine what might be realistically considered for the project. By going through this pre-feasibility exercise, it will help stimulate creative solutions early into the project. No detailed technical studies will be undertaken in this task.

- Prepare list of DC and AC transmission options for further study. This list will only be finalized after transmission owners and the WSCC and WAPA transmission managers have reviewed the options recommended. This list will identify how much excess capacity exists on the system currently, and what other new generation capacity is expected to compete with the identified renewables to use the system. This list will also emphasize budget costs, expected economic effectiveness and commercial benefits.

Deliverables:

1.1.1a - Recommended List of Transmission Options.

Task 1.1.2: Investigate Feasibility for Interconnecting to the Pacific HVDC Intertie
The objective of this task is to investigate in greater detail, the technical options for DC transmission and in particular, for adding an interconnection to the HVDC system. Possible options might include:

- Parallel HVDC interconnection
- Parallel Voltage Source Converter (VSC) interconnection
- Series VSC interconnection
- Replace shield wires on the HVDC towers with insulated conductors and use them for power transmission
- Add additional towers on the same right-of-way with sufficient clearance for new conductors.

The Contractor shall:

- Analyze the performance of each option to ensure satisfactory operation with the existing HVDC link and the new "green" energy sources. Several ratings will also be investigated.

- Develop and test a working model of the HVDC system using the PSCAD/EMTDC simulation package. This program is the worldwide standard for HVDC system studies and is used by all the major manufacturers for the development of their HVDC equipment and controls. The program is also capable of modeling Voltage Source Converters (VSC) and wind generation. Assistance from the operators of the Pacific HVDC Intertie (Los Angeles Department of Water and Power (LADWP) and BPA) is essential for this stage of the model development. The required contacts are partners in this agreement and have agreed to provide model parameters, accurate electrical network data and HVDC control system block diagrams. These utility partners can also contact the manufacturer of the equipment to obtain models.

  A simulation of the Pacific HVDC Intertie for the selected interconnection method(s) will be added to the model. It will be set-up so that performance due to many faults and disturbances can be evaluated. In order for this model to be used by third parties, it is conceivable that permission will be required from the power utilities that have provided the required information used by the model. Any parties wanting to perform their own simulations would also have to have access to the PSCAD simulation program.

Generic device and control strategies will be used for the Pacific HVDC Intertie model and for the new interconnections. It is anticipated that considerable upgrading on the HVDC Intertie will have been undertaken and its control and protections will not be known when this study is to be done. A generic model will function with the correct time constants and major system behavior, but will not be an exact replica of the actual controls, whatever they might be. Generic models will be sufficient for this feasibility study, but exact models with an accurate controls implementation are preferred.

The importance of this detailed level of simulation will be evident in studies examining the interconnection to renewable energy sources at midline. Interactions such as commutation failure will have a significant effect on the performance of the Intertie and therefore need to be modeled with precision. A key parameter in the evaluation of each interconnection is to ensure that it impacts minimally on the operation of the existing HVDC system. The studies undertaken will evaluate the down-stream impact of adding an interconnection to the renewable energy sources.

- Prepare an Interconnection Model Development Report describing the various interconnection technologies and controls required. The report will contain comparisons of each interconnection technology and waveforms showing the impact on the existing HVDC system. The report will describe in detail the risks associated with the interconnection to the Pacific HVDC Intertie and make a recommendation on the technical acceptability of doing so.

Deliverables:

1.1.2a - Transient Simulation Model with the Interconnection Added
1.1.2b - Interconnection Model Development Report

Task 1.1.3: Investigate Feasibility of Use of AC Transmission.

The Contractor shall:

- Investigate options to directly connect new renewable energy sources in the target area to AC transmission. This is a second option to the use of the Pacific Intertie as a method of transmission to study. There are AC transmission lines of limited capacity at present existing near the California – Nevada border area where the renewable energy sources might be developed. For example, the WSCC summer year 2000 maximum transfer capacity into Northern California from the Reno region was only 160 MW. It is anticipated there are several thousand MW of potential renewable energy sources that could be developed in this region. The limitations at present existing in transfer capability on existing AC transmission into the Northern and Southern California load centers from this region of interest are not capable of supporting any significant additional capacity. These limited AC transmission lines for use as a feeder to the Northern California load center in particular, will be investigated, with recommendations made for capacity upgrades.

  Consideration will also be given to the WAPA Central Valley Project where there are some key AC transmission lines that also provide access to the hydroelectric resources of the region with potential energy storage capability.

  There are significant capacity upgrades that can be made for AC transmission. For example, a double circuit 230 kV AC line at present under study by Electranix Corporation, when converted to DC transmission, would result in a capacity increase from its 1000 MW thermal limit to 2500 MW; a 1500 MW increase. Other AC transmission upgrading options to study are use of series compensation and/or Flexible Ac Transmission Systems (FACTS).

  An important criteria for determining acceptable transmission options is that the transient and steady state AC voltages at all substations feeding the distribution systems must remain within the normal, acceptable ranges so that there is no deterioration of power quality. If anything, power quality should be enhanced by the upgrade and the new facilities that might be needed. To do so may require use of FACTS technologies.

These results of this task will be compared to those from the previous task (which investigated options for HVDC Intertie interconnections).

Comparisons of AC and HVDC interconnections will consider:
- Cost comparison of each interconnection
- Technical performance and reliability
- Environmental aspects.

- Prepare a Feasibility of AC Transmission Interconnections Report that fully documents the work in this task.

Deliverables:
1.1.3a - Report on the Feasibility of AC Transmission Interconnections

Task 1.1.4: Determine Optimum Interconnection Location(s)

The Contractor shall:

- Determine the optimum location(s) for an interconnection to the DC and AC transmission options by studying the location and quantity and quality of renewable energy resources in the area, as well as location of available transmission. These resources include:
  - Wind
  - Geothermal
  - Photo-voltaic (PV)
  - Existing hydro.

  Coordination with the Team's Energy Resource Advisor and PPREAT participants will determine current and forecasted renewable energy resources for the area. Considerations will be given to more than one interconnection point if AC collector grid systems in place are not sufficient or have high environmental impacts if constructed (see also Task 7). Identification of what capacity can be fast-tracked will provide a factor in locating the interconnection.

  The recommended location of the interconnection will be based on technical and economic considerations and will include possible environmental impacts. Although an environmental impact study is not included in this contract, the minimization of new transmission facilities is one measure of environmental impact. In other words, the less new transmission, the less environmental impact there will be.

  Other factors to be evaluated that will have an impact on determining the interconnection points will include firstly, minimization of transmission losses by placing a suitable cost to their value. Secondly, AC system voltage support to ensure there is no degradation of power quality to nearby loads. The value placed on the cost of losses should reflect the reduction in SOx, NOx, CO and CO_2 emissions that result elsewhere in the power system if transmission losses are minimized.

- Prepare an Optimum Interconnection Location Report that fully documents the work in this task.

Deliverables:
1.1.4a - Report on the Optimum Interconnection Location

Task 1.1.5: Investigate AC Collector Grid Configurations and Options.

The Contractor shall:

- Evaluate possible transmission collector systems to bring energy to the interconnection point(s) for connection to the main transmission lines studied in the above tasks from the sites of renewable energy near the California–Nevada border. It is necessary that the order, in which the new renewable energy sources will be developed, be known so that the evaluation of the collector system can be staged accordingly.

  In planning possible collector grid layouts, existing transmission facilities in the area such as from the Sierra Pacific Power Company's grid will be taken into account.

  Consideration will be given to environmental, economic and technical restraints that might apply as each collector system is investigated.

  To configure a collector grid to bring in the power from the various sites of renewable generators, the task will assume that the following information will be available through coordination with the various agencies, operators and resource experts:
  - Number of developed sites and where they are located.
  - Total capacity of identified sites
  - Competitive economics of each site
  - Utilization of transmission assets

  For sites not yet developed, the following information will be sought, noting that not all of it may be readily available or can be found within the resources allocated to this project:
  - Location
  - Estimated resource
  - Estimated capacity
  - Property ownership
  - Proximity to other renewable resources
  - Transmission access
  - Environmental issues
  - Property tax analysis
  - Land use issues
  - Construction issues

- Prepare an AC Collector Grid Configuration and Options Report. The report will contain a short summary of each site and the interconnection issues surrounding that will be included in the deliverable for this task. The summary will include a set of pro-formas, one for each candidate site sufficient to help locate the collector system and prioritize doing so. A detailed report on each site is beyond the scope of this project.

Deliverables:

1.1.5a - Report on AC Collector Grid Configuration and Options

Task 1.1.6: Study System Operational Performance.

The Contractor shall:

- Conduct additional studies to study longer term phenomena and performance of the overall power system involving:
  - Voltage stability
  - Power system stability
  - System resonance and harmonic stability
  - Inter-area oscillations
  - Reliability assessment on the supply of energy to the load.

  The technical behavior of the AC and DC interconnection options was studied in Tasks 1.1.2 and 1.1.3. This task requires a working model of the new transmission configurations and will require additional modeling and study work on a suitable transient stability program.

  Transient stability data and assistance from the partnering utilities LADWP, BPA and others will be coordinated. Existing transient stability models will be updated to reflect the selected interconnection technologies.

- Prepare an Overall Operational Acceptability Report that fully documents the work in this task.

Deliverables:

1.1.6a - Report on the Overall Operational Acceptability

Task 1.1.7: Costing and Economic Analysis of the Interconnection.

The Contractor shall:

- Analyze the direct economic impact of the selected interconnection. The costing information will include the following estimated cost and benefit assessment:
  - Construction costs associated with the interconnection
  - Cost savings due to increased availability of energy
  - Energy transmission loss calculations
  - Cost of unavailability due to transmission and equipment forced outages
  - Expected return on investment.

  Determination on how much carbon will be displaced by injection of renewable energy planned for development in the region of interest will be undertaken. Although carbon credits may not be available to include in the economic assessment, at least an estimate of what such credits could be worth should be evaluated.

- Prepare an Economic Analysis of Interconnections Report. The report will contain a recommendation on what transmission upgrading to use for the proposed renewable energy developments in the California – Nevada border region. A draft of this report will be distributed to transmission owners and operation managers in the regions affected to obtain their input and eventual concurrence. Such inputs will be reflected in the report prepared for this task.

Deliverables:

1.1.7a - Report on the Economic Analysis of Interconnections.

Task 1.1.8: Final Project Report

The Contractor shall:

- Prepare the Final Report on this project, in accordance with the process described in Project 0.6, that makes recommendations for the feasibility of upgrading existing DC (the Pacific HVDC Intertie) and AC transmission for feeding power from the renewable energy sources proposed for development near the California – Nevada Border. The final report will include:
  - A recommendation of the best method of interconnection (based on technical, economic and basic environmental evaluations)
  - An evaluation of the impact on the existing HVDC link
  - Identification of the optimum location(s) for an interconnection
  - An evaluation of the impact an interconnection will have on overall system stability and operation
  - An assessment of AC collector system configurations and options for the renewable energy sources at interconnection points
  - Development costs and possible return on investment.
  - A plan for grid operations and commercialization of the proposed project.

Deliverables:

1.1.8a - Final Report on the Feasibility of Interconnecting the HVDC Intertie

Key Personnel:

None

Key Subcontractor:

Dennis Woodford**,** Electranix Corporation

PROJECT 1.2: New Wind Site Identification and Qualification

Problem Statement

This project focuses on the identification of new, and developable, wind energy generation sites in California and neighboring states that will have the ability to access the Pacific HVDC Intertie and that may also add value to the generation, and energy storage, capabilities of the Central Valley Project. The economic constraints of constructing an interconnection to the HVDC Intertie require large generation facilities in order to amortize those costs. Therefore, an important part of the site analyses will be to quantify the potential capacity of each site. Qualification of the sites will be based on several key variables, (i) estimates of the renewable resource, (ii) proximity to transmission lines, (iii) environmental and permitting issues, and (iv) project economics. In addition, due to the synergies realized when integrating wind with natural gas fired and geothermal generating stations, the locations of these supplies (gas lines and geothermal resources) will be included in the analyses.

Prior Research

California has been, and continues to be, a vibrant development market for renewable energy projects. The United States wind industry began in California in the early 1980s, aggressively motivated by tax credits at the federal and state levels. The geothermal industry developed in California as well, with large facilities constructed. Each of these industries has studied the renewable resources extensively and a large body of research is available. However, commercial developers protect proprietary research diligently, so detailed costs and project economics are difficult to obtain.

Three prominent areas in California have emerged as the dominant wind resource development locations, Altamont Pass east of San Francisco, San Gorgonio near Palm Springs and Tehachapi Pass east of Bakersfield. These locations have been developed extensively. Commercial developers have studied additional locations in California, but that data is unavailable for competitive reasons.

Distributed Generation Systems, Inc. (Disgen) has been developing wind energy projects since 1996 and has developed the first commercial wind facilities in Colorado and Pennsylvania and has commenced construction in Massachusetts. In addition, Disgen's principal, Dale Osborn developed the first commercial wind project in Texas for Kenetech Corporation and the Lower Colorado River Authority. Each of these first projects required a thorough analysis of the state's renewable resources similar to the process described in this project for California and its neighboring states.

Baseline Conditions

The number and total megawatts of potential capacity, of new developable renewable energy sites identified and qualified will measure success of this project. In order to qualify, a site must be, (a) economically feasible, (b) environmentally sound, (c) provide energy into the system such that PPREAT participants benefit, and (d) can achieve operational status in less than ten (10) years. The total capacity of the projects must exceed the existing capacity of non-hydro renewable energy in California currently.

Project Goals

Upon successful completion of the site identification and qualification process, it is expected that the following benefits may be realized with commercial development:

- Over 2000 MW of new renewable generation to supply California
- Corresponding reduction in fuel price risk
- Offsetting emissions from traditional power generating stations
- Increased utilization of existing transmission assets
- Economic development activity in excess of $4,000,000,000.

This program will define a development plan to achieve these five benefits. The continued evolution of the renewable technologies and their ongoing lowering of costs will make these technologies economically and environmentally superior to other generating technologies. When combined with the energy storage cooncepts being advanced, the synergies create a future of lower cost power and more environmentally sound energy planning.

Project Objectives

Identify and quantify the potential sites, including a ranking of the sites based on project economics. It is expected that at least twenty (20) developable sites will be identified. However, the size of the projects required to support the cost of interconnection to the HVDC Intertie will limit the number of such sites.

Performance Metrics

- Number of developable sites identified
- Total capacity of identified sites
- Competitive economics of each site
- Utilization of transmission assets
- Synergies with storage, HVDC Intertie and Central Valley Project
- Usefulness to PPREAT members

Project Work Plans

Task List:

Task 1.2.1	Candidate Site Identification
Task 1.2.2	Candidate Site Interconnection and Economic Analysis
Task 1.2.3	Resource Monitoring and Permitting
Task 1.2.4	Final Report

Task 1.2.1: Candidate Site Identification

The objective of this task is to identify candidate renewable energy generation sites in California and neighboring states through the analyses of available data and the creation of new data.

The Contractor shall:

- Review all available resource (including known geothermal locales) information, including maps provided by NREL, examine topographical maps for unique features, correlate transmission line and natural gas pipelines with potential sites and define a site visitation plan. The review shall include the information being developed under the PIER contract with True Wind Solutions. New wind resource sites will incorporate GIS information as well as new California resources maps.

- Conduct site visits, focusing on evidence of resource, transmission proximity, environmental issues and ease of access.

- Identify the candidate sites as privately or publicly owned properties and estimate the capacity of each site. During the site visits, gather local economic information relative to property and sales taxes and shall obtain any local zoning or land use rules and regulations associated with the sites. The candidate sites within reasonable proximity to HVDC Intertie will receive priority.

- Prepare a Candidate Site Report. This report shall include a list of candidate sites with the following information:
    - Location
    - Estimated resource

- Estimated capacity
- Property ownership
- Proximity to other renewable resources
- Transmission access
- Environmental issues
- Property tax analysis
- Land use issues
- Construction issues

A discussion of synergies between candidate sites, natural gas supplies, geothermal resources, and the HVDC Intertie and storage opportunities in conjunction with WAPA's Central Valley Project.

- Consult with other members of PPREAT to obtain their concurrence and provide recommendations for a short-list of sites to be considered further.

Deliverables:
1.2.1a Candidate Site Report

Task 1.2.2: Candidate Site Interconnection and Economic Analysis
The objective of this task is to define the key economic parameters of each candidate site and to create a set of estimated project economics for each site in order to provide PPREAT with a ranking capability for the sites.

The Contractor shall:
- Assess the project economics by determining the capabilities of the transmission system. Contractor shall work with the transmission utilities and members of PPREAT to conduct studies of the existing transmission system, the upgrades required, if any, and the limitations of the existing system. Preliminary designs of interconnection facilities and required upgrades will be determined and the costs associated with those activities defined. Project economics depend significantly on the financing structure assumed. A project owned by a tax-exempt entity, for example, would likely have better economics than one project financed utilizing institutional investors. For the purpose of comparing sites, Contractor will use a standard institutional project pro-forma structure. Once specific sites are selected, Contractor can modify the variables to provide PPREAT members with an analysis of financing structures required.
- Prepare an Interconnection Issues Surrounding Each Candidate Site Report.
- Prepare a set of project pro-formas to provide comparative estimated economics per site.

Deliverables:
- 1.2.2a - Interconnection Issues Surrounding Each Candidate Site Report
- 1.2.2b - A set of project pro-formas.

Task 1.2.3: Resource Analysis and Preliminary Environmental Assessment
The objective of this task is to complete the data set necessary to provide developers and financial institutions with sufficient information to proceed with financing and construction on at least five sites.

The Contractor shall:
- Prepare a Renewable Resource Analysis Test Plan. This plan explains how data will be gathered at the candidate sites. In order to accomplish this activity, resource instrumentation must be installed and data collected and analyzed by a qualified meteorologist or other specialist. The data collection is achieved through the installation of specialized recording instrumentation. The data is customarily accumulated over at least one year. Diligent maintenance of the data collection equipment is essential for quality data set. A

professional person, with experience in providing financeable information, must perform the analysis of the data. The instrumentation required might be as little as one monitoring device, or many, depending upon the size of the site.   In order to collect data on a project size required to interconnect to the HVDC Intertie, for example, twelve or more instruments could be required for a wind facility. The test plan shall include an assessment of the Plumas Sierra wind site.

- Analyze the candidate sites in accordance with the test plan.

- Prepare a Renewable Resource Analysis Test Report. This report shall include raw, hour by hour data collected for each renewable resource for each site.

- Prepare a Preliminary Environmental Assessment of the land use permitting issues associated with the candidate sites. In wind energy projects, potential avian and visual issues dominate the local concerns. Preliminary assessment of avian issues and other flora and fauna issues are needed in order to determine if a site should be eliminated. Often, the economic development benefits accruing to a community from the deployment of renewable projects will ease the concerns. However, preliminary assessment of these issues must be conducted and formal studies conducted if the initial research warrants.

Deliverables:

- 1.2.3a - Renewable Resource Analysis Test Plan
- 1.2.3b - Renewable Resource Analysis Test Report
- 1.2.3c - Preliminary Environmental Assessment

Task 1.2.4: Final Project Report
The goal of this task is to prepare a Final Project Report.

The Contractor shall:

- Prepare the Final Report on this project, in accordance with the process described in Project 0.6.

Deliverables:
- 1.2.4a – Final Report Outline for the New Wind Site Identification and Qualification Project
- 1.2.4b – Draft Final Report for the New Wind Site Identification and Qualification Project
- 1.2.4.c – Final Report for the New Wind Site Identification and Qualification Project

Key Personnel:
None

Key Subcontractors:
Dale Osborn, President, Distributed Generation Systems, Inc. (Disgen)

PROJECT 1.3: New Geothermal Site Identification and Qualification

Prior Research

GeothermEx will leverage prior work to the fullest extent possible. Prior research undertaken by the United States Geological Survey (USGS) and the United States Department of Energy (USDOE) has identified all of the resources that will be evaluated. In 1978, the USGS estimated the potential generating capacity of many of these resources; however, GeothermEx has significantly improved the methodology used at that time. In addition, during the past 28 years, GeothermEx has worked in most of these areas, both developed and undeveloped, and has participated in the successful exploration and development of more than 6,000 MW of geothermal power around the world. GeothermEx has also conducted pioneering assessments of combined gas and geothermal projects and low-BTU natural gas projects for a private client and for the Sacramento Municipal Utility District, respectively.

GeothermEx will be assisted by the USDOE via technical project support in resource characterization from the Idaho National Engineering and Environmental Laboratory (INEEL). The unique combination of prior research, GeothermEx's real-world experience with commercial geothermal project development and the contribution of USDOE (via INEEL) will enable a timely and realistic assessment of the geothermal resources located within 50 miles of the HVDC Intertie.

Baseline Conditions

There are two types of baseline conditions for this project: 1) the existing portfolio of geothermal resources currently being used for power generation and the amount of power generated from them; and 2) the knowledge base of these and other geothermal resources located within 50 miles of the HVDC Intertie. Therefore, increasing the level of generation from and/or increasing the level of interest in developing these resources can be considered as measures of the success in achieving our goal.

Project Goals

There are several obstacles facing geothermal development today. Perhaps the most significant is that all of the large geothermal resources currently known have already been developed, with the exception of the Glass Mountain (Medicine Lake) resource, which is an important identified geothermal field located in the northeastern part of the state. Therefore, the majority of the known geothermal resource sites that remain to be developed have smaller prospects, and as a result, are of less interest to developers owing to the high up-front costs associated with geothermal development. The PPREAT approach seeks to mitigate this problem by aggregating renewable resources in a way that achieves greater economies of scale, thus promoting interest among various types of potential project developers.

We anticipate that this realistic portfolio of geothermal projects, complete with the required steps and costs to achieve the stated generation potential in each, will result in a significant new phase of geothermal resource development in the United States and an increase in the number of entities participating in geothermal projects. In keeping with the desire to minimize power development and particularly transmission costs, the greatest potential for increased geothermal development may well occur in areas where geothermal projects can be collocated with other generation facilities, particularly those fueled by wind and natural gas. Geothermal could supply the base-load power at such sites, while the other technologies could provide the peaking capacity. The result will be an increase in renewable generation in California, further diversifying our power mix. Furthermore, the collocation approach will increase the affordability of geothermal projects by minimizing transmission costs.

Based on a recent survey of developers' plans over the next 3 to 5 years conducted by GeothermEx, we have estimated the potential for an increase of up to 600 MW in the total installed geothermal capacity, which is about 2,400 MW in California today. Therefore, the development of 600 MW of additional geothermal generation in the next 5 years is a reasonable estimate for the whole state. We conservatively believe the results of this project will help continue this momentum, resulting in some 1,200 MW of new geothermal power capacity in the state in the next 10 years, and 1,800 MW of new capacity in the next 15 years. It is likely that implementation of this project will significantly accelerate this expansion scenario. We believe the total capacity of potential projects within 50 miles of the HVDC intertie will be approximately half of the total capacity of all geothermal projects in California. Therefore, our approximate, conservative estimates of the increase in generation capacity within 50 miles of the HVDC intertie due to the results of implementing this project are 300 MW, 600 MW and 900 MW within 5 years, 10 years and 15 years, respectively.

Project Objectives

The objective of this project is to provide a portfolio of well-characterized geothermal resources located within approximately 50 miles of the HVDC Intertie, thus promoting: 1) the development of new geothermal power projects; and/or 2) an increase in the generating capacity at existing geothermal projects. This will be accomplished by characterizing and quantifying each resource in terms of its minimum and most-likely generating capacity, determining and estimating the costs of exploration and/or development required to reach those capacities, and calculating the associated total development costs and unit development cost ($/kW installed). The development cost will include transmission tie-in costs, as determined by other participants in this project.

Performance Metrics

As mentioned above, our objective is to increase the amount of geothermal generation in California by bringing new resources on line or adding capacity at existing resources. Therefore, the ultimate measure of our success will be in achieving such an increase. However, since in a geothermal development several years elapse between the identification/characterization of the resource and the generation of electricity from it, a more appropriate and realistic measure of success would be an increase in the level of interest and activity in geothermal exploration. The current energy situation in the west has already caused increased interest in the expansion, sale or purchase of existing geothermal facilities; however, interest in developing new resources continues to lag. The agencies that control geothermal lease acquisition and issue permits for exploration work, drilling and siting of geothermal plant facilities could easily be surveyed to determine if an increase in activity has occurred in the next few years following this work.

Project Work Plans

There is a wide disparity in the data available from the various geothermal sites. Some have existing facilities with long production/injection histories that would allow an accurate assessment of the ultimate potential of the field, setting the stage for possible capacity expansions. Others may have enough drilling information to prove the existence of commercial production conditions; even with no production history, it should be possible to determine the resource criteria that are required to determine the field's generating capacity. At the other end of the spectrum, there are sites where a geothermal resource has been identified from surface exploration, but no deep drilling has been conducted to confirm the presence of a commercial reservoir.

To carry out the resource assessment in the face of this database disparity, we will quantify for each site a uniform set of minimum required resource criteria that determine the commercial feasibility of a project. Based on an analysis of the relevant parts of the available database, these criteria will form part of the input to the estimation of the generation capacity for the site. Fortunately, the minimum criteria are always quantifiable for each identified site, albeit with different levels of uncertainty. To rigorously take this uncertainty into account, we will associate the estimate of each criterion in the set with an "error bar." (An error bar around the estimate of a parameter implies that the parameter has an approximately normal probability distribution around the estimated value.) We will then use probabilistic simulation (based on Monte Carlo sampling) to quantify the uncertainty associated with the resulting estimate of generation capacity.

The estimation of the minimum resource criteria, along with the associated error bars, for each site will be accomplished through an integrated analysis of the relevant database available for the site. The procedure is discussed in more detail below. We will quantify the value and associated error bar (range of uncertainty) for the following criteria:

- reservoir volume;
- reservoir temperature;
- reservoir depth; and
- power capacity per well.

From these, we will use a probabilistic approach to estimate the minimum and most-likely generation capacity at each site, the unit development cost ($/kW installed) and the total development cost associated with the minimum and most-likely generation capacities.

Each site will have certain associated operational constraints, which may be difficult to quantify. These constraints are typically associated with fluid chemistry (*e.g.*, scaling, corrosion and non-condensable gas content in steam), terrain, access and other institutional or infrastructural factors. We will provide a list of operational constraints that may occur in each area, thus enabling a qualitative assessment of how operational constraints may be mitigated and how the constraints may affect the development cost for each site.

Task List:

Task 1.3.1	Acquire and assess resource data
Task 1.3.2	Estimate generating potential
Task 1.3.3	Develop statistical correlations required to estimate drilling costs
Task 1.3.4	Estimate exploration and resource confirmation costs
Task 1.3.5	Estimate development costs
Task 1.3.6	Assess and acquire resource data
Task 1.3.7	Estimate generating potential
Task 1.3.8	Estimate exploration and resource confirmation costs
Task 1.3.9	Estimate development costs
Task 1.3.10	Final Project Report

Task 1.3.1: Acquire and assess resource data
The objective of this task is to analyze existing data to determine the reservoir parameters required to estimate generating potential and development cost for each of approximately 20 known geothermal resource sites located within 50 miles of the HVDC Intertie.

The Contractor shall:

- Compile data, using published data and information from GeothermEx's files of non-proprietary resource information, on resource size (depth, area and thickness), temperature, well productivity (if wells have been drilled) and operational constraints (*e.g.*, fluid chemistry problems, access, terrain, etc.) to be used as input to the following tasks.

- Prepare a Geothermal Resource Database. This database shall include resource parameters and operational constraints on development for each of approximately 20 geothermal resource sites located within 50 miles of the HVDC Intertie.

Deliverables:
1.3.1a - Geothermal Resource Database

Task 1.3.2: Estimate generating potential
The objective of this task is to estimate the generating potential of the approximately 20 known geothermal resource sites located within 50 miles of the HVDC Intertie.

The Contractor shall:

- Prepare a Resource Criteria Database. This database shall include associated error bars and minimum and most-likely generating potential for approximately 20 geothermal resource sites located within 50 miles of the HVDC Intertie._Generation potential depends upon several factors, the most critical being the volume and temperature of the reservoir. We intend to estimate and use these factors as follows:

  Reservoir volume will be estimated from the reservoir area and thickness defined in the first task, the uncertainty associated with each parameter defining the overall error bar for the estimate. For fields under exploitation, this criterion can be estimated relatively accurately based on published exploration data, drilling results and production history. For proven but undeveloped sites, the reservoir volume will be estimated from the exploration database and drilling results; however, the lack of a production history will widen the error bar in the estimate. For explored fields without any "discovery" wells, the reservoir area can be approximated as the area of the "thermal anomaly" defined by exploration. For these latter sites, the reservoir thickness will be approximated as the difference between the depth to the reservoir top (as interpreted from temperature gradient data) and a maximum reasonable drilling depth. The reservoir volume thus estimated for these sites will necessarily have a even wider error bar.

  Resource temperature will be estimated from a comparative analysis of both drilling and production data for the developed fields. For proven but undeveloped fields, temperature will be estimated from the drilling results and geothermometry (*i.e.*, temperature estimation from chemical analysis of fluids) based on samples collected from wells. For sites that have been explored but not yet drilled, temperature will be estimated from geothermometry based on fluid samples from springs, fumaroles and shallow wells. The error bar in temperature estimation will be estimated for each site.

These parameters will then be used to estimate the generating potential of each site as follows. From the estimated reservoir volume and temperature, the thermal energy reserves (R_t) above a minimum utilizable resource temperature can be calculated as follows:

$R_t = V (T - T_{min}) C_v$

Where V is the volume of the reservoir, T is the temperature of the reservoir, T_{min} is the minimum utilizable resource temperature, and C_v is the volumetric specific heat of the reservoir (fortunately, the values of C_v for geothermal reservoirs fall within a narrow range; therefore, we can use the same value for all sites). However, not all of this thermal energy can be recovered at the surface; furthermore, only a fraction of the recovered heat can be converted to electrical energy. One can calculate the available electrical energy reserves (R_e) from the estimated thermal energy reserves as follows:

$R_e = R_t \cong r \cong e$

where r is the recovery factor (the fraction of thermal energy in the reservoir that can be recovered at the wellhead) and e is the thermal-to-electric energy conversion efficiency. Unfortunately, r is very difficult to estimate; it could be estimated accurately only through rigorous numerical simulation of reservoir fluid flow and heat transfer, calibrating the simulation model against a history of prolonged production and injection. Such an estimation is possible only for fields under exploitation, and the exercise would require a disproportionately large effort compared to the other aspects of this project. Therefore, we will use an assumed recovery factor for each site based on our experience in such assessments of other sites around the world. In 1978, the USGS proposed a recovery factor of 0.25; however, experience since then has shown that it is likely to be significantly lower. Based on our assessment of more than 100 geothermal sites around the world, we have found that a recovery factor in the range of 0.05 to 0.2 is more realistic. For a specific site, this range can be narrowed down based on an integrated analysis of the available exploration, drilling and production databases.

Energy conversion efficiency (e) is the fraction of recoverable thermal energy that can be converted into electrical energy. Although this factor depends on the power conversion technology used, a reasonable approximation is possible simply from the estimated resource temperature using the First and Second Laws of thermodynamics, as described by the USGS in their pioneering work in this area in 1978. Assuming a power plant life of 30 years and a plant capacity factor of 90%, both of which are typical for geothermal projects, the maximum power capacity for each site can be calculated from the electrical energy reserves. This is the method we will use to estimate the generation capacity, with an associated error bar, for each site.

For conducting Monte Carlo simulation of the generation capacity estimate, reservoir volume and temperature will be assumed to have an approximately normal distribution, with the error bar defining a span of about two standard deviations around the estimate. The recovery factor will be assumed to have a “rectangular distribution” such that all values of recovery factor within the chosen range will have an equal probability. The remaining parameters needed for the estimation will be assigned fixed values. Through Monte Carlo simulation, the frequency distribution and cumulative probability distribution of the generation capacity at each site will be developed. From these computations, estimates will be made of the proven or minimum capacity (defined as the generation capacity value with a cumulative probability of more than 90%) as well as the most-likely value (defined herein as the modal generation capacity).

Deliverables:

1.3.2a - Resource Criteria Database

Task 1.3.3: Develop statistical correlations required to estimate drilling costs
The objective of this task is to determine the relationship between: 1) reservoir depth and drilling cost; and 2) reservoir temperature and well power capacity.

The Contractor shall:

- Prepare a Statistical Correlations Report. This report shall include drilling costs, which are a large fraction of the up-front costs required for geothermal power generation, so the economics of drilling strongly impact the profitability of a geothermal project. Therefore, prior to estimating the unit development cost of a project, reliable relationships must be developed that define expected drilling cost (as a function of reservoir depth) and expected per-well power capacity (as a function of temperature). Both of these subjects were studied extensively in the early 1980s. However, since then, a great deal more data have been collected on actual geothermal operations around the world. Since this task takes a statistical approach, GeothermEx can leverage its extensive experience in geothermal projects around the world without compromising data confidentiality. GeothermEx conducted such a statistical study in 1987 for the Electric Power Research Institute. We will estimate drilling costs in 2001 dollars as a function of the resource depth, and use the large body of statistical data on well power capacity as a function of reservoir temperature (assuming a constant well completion diameter) to estimate the most likely power capacity per well.

Deliverables:

1.3.3a - Statistical Correlations Report

Task 1.3.4: Estimate exploration and resource confirmation costs
The objective of this task is to estimate a realistic set of exploration and resource confirmation costs for the geothermal resource sites located within 50 miles of the HVDC Intertie that have not been proven by deep drilling and testing to date.

The Contractor shall:

- Prepare an Exploration and Drilling Cost Database. This database will include drilling costs required to prove the existence of greenfield geothermal resources located within 50 miles of the HVDC Intertie. Some of the resource sites located in the area of interest have not yet been proven by drilling and testing. Before sites for deep exploration wells can be selected, project developers typically undertake various kinds of exploration work (geology, geophysics, geochemistry, slim holes, etc.) to better characterize the resource and narrow down the number of potential drilling sites. For this task, we will determine a reasonable set of exploration survey methods required prior to selecting drilling targets and estimate the costs of each. We will then estimate the cost required to prove the resource by drilling a few deep exploration wells (the number of wells required to confirm the resource can reasonably be expected to depend on the overall generating capacity; that is, fewer confirmation wells would be required for a resource that is expected to support a smaller level of power production). It is emphasized that the exploration and resource confirmation programs identified in this task by GeothermEx and INEEL are not necessarily the ones that will be followed by a geothermal developer, since every developer brings its own experience and bias to the exploration/confirmation process.

Deliverables:

1.3.4a - Exploration and Drilling Cost Database for resources located within 50 miles of the HVDC Intertie

Task 1.3.5: Estimate development costs
The objective of this task is to estimate the unit development cost in terms of dollars per kW installed and the total costs associated with the minimum and most-likely values of generating capacity for approximately 20 geothermal resource sites located within 50 miles of the HVDC Intertie.

The Contractor shall:

- Prepare a Unit and Total Development Cost Database. The generation potential for a site can only be realized if energy can be extracted from the reservoir economically. While there are many factors that affect the economics of a project, the most critical are reservoir depth and production capacity per well. Reservoir depth largely determines drilling costs, which typically comprise about 30% of the field development costs and a significant portion of the operations and maintenance costs. The depth to the reservoir can be estimated using data from existing deep wells or from temperature gradient holes. Using the above-described statistical database on drilling costs versus depth, we will estimate drilling cost per well with an appropriate error bar for each site.

  Power capacity per well dictates how many wells will be needed for a given power plant capacity, and how many replacement wells may be needed to maintain the generation capacity over the life of a plant (assuming a well degradation rate typical of geothermal wells). As such, this criterion affects both the capital cost and the operations and maintenance (O&M) cost of a project.

  Both per-well cost and per-well power capacity will be used as input to determine the cost of generation at each site. Other inputs will include the resource exploration and confirmation cost described above, and the cost of connecting to the transmission system (using input from other members of the PPREAT team) and a typical unit cost for power plant and gathering system (we will use $1,500 per kW installed as of 2001). These costs will be expressed as the total costs associated with the minimum and most-likely generation level at each site, and the unit development cost ($ per kW installed) for the two possible generation levels.

Deliverables:
1.3.5a - Unit and Total Development Cost Database for the minimum and most-likely generating capacities at approximately 20 geothermal resource sites located within 50 miles of the HVDC Intertie.

Task 1.3.6: Assess and acquire resource data
The objective of this task is to analyze existing data to determine the reservoir parameters required to estimate generating potential for each of approximately 8 major known geothermal resource areas in California (those not located near the HVDC intertie).

The Contractor shall:

- Prepare a Resource Parameter and Operational Constraint Database. Using published data and information from GeothermEx's files of non-proprietary resource information, compile data on resource size (depth, area and thickness), temperature, well productivity (if wells have been drilled) and operational constraints (*e.g.*, fluid chemistry problems, access, terrain, etc.) to be used as input to the following tasks.

Deliverables:
1.3.6a Resource Parameter and Operational Constraint Database

Task 1.3.7: Estimate generating potential
The objective of this task is to estimate the generating potential of the approximately 8 major known geothermal resource areas in the State of California (those not located near the HVDC intertie).

The Contractor shall:

- Prepare a Generating Potential Database for the 8 known major geothermal resource areas in California. This database shall include resource criteria, associated error bars and minimum and most-likely generating potential. Generation potential depends upon several factors, the most critical being the volume and temperature of the reservoir. We intend to estimate and use these factors as described in the previous task. The minimum and most-likely generation capacity will be determined by Monte Carlo simulation, in which reservoir volume and temperature will be assumed to have approximately normal distributions (with the error bar defining a span of about two standard deviations around the estimate), and recovery factor will be assumed to have a rectangular distribution (all values within the range being equally probable). All other parameters needed for the estimation will be assigned fixed values. The frequency distribution and cumulative probability distribution of the generation capacity at each site will be developed. From these computations, estimates will be made of the proven or minimum capacity (defined as the generation capacity value with a cumulative probability of more than 90%) as well as the most-likely value (defined herein as the modal generation capacity).

Deliverables:
1.3.7a Generating Potential Database for the 8 known major geothermal resource areas in California.

Task 1.3.8: Estimate exploration and resource confirmation costs
The objective of this task is to estimate a realistic set of exploration and resource confirmation costs for the geothermal resource areas in the State of California, located more than 50 miles from the HVDC intertie, that have not been proven by deep drilling and testing to date.

The Contractor shall:

- Prepare an Exploration and Drilling Cost Database for resources located more than 50 miles from the HVDC Intertie and within the State of California. This database will include exploration and drilling costs required to prove the existence of the greenfield geothermal resources within this area. As defined for the previous project, we will determine a reasonable set of exploration survey methods required prior to selecting drilling targets and estimate the costs of each, and then estimate the costs required to prove the resource by drilling a few deep exploration wells.

Deliverables:

1.3.8a Exploration and Drilling Cost Database for resources located more than 50 miles from the HVDC Intertie and within the State of California

Task 1.3.9: Estimate development costs
The objective of this task is to estimate the development cost in terms of dollars per kW installed (unit development cost) and the total costs associated with the minimum and most-likely values of generating capacity for the approximately 8 known major geothermal resource areas in California, located more than 50 miles from the HVDC intertie.

The Contractor shall:

- Prepare a Total and Normalized Development Cost Database. This database will include costs for the minimum and most-likely generating capacities at each of the approximately 8 known major geothermal resource areas in California located more than 50 miles from the HVDC intertie. Using the available data and the previously determined statistical correlations (between well depth and drilling costs, and between temperature and well power capacity) we will estimate the per-well costs and per-well power capacity, which will then be used as input to determining the costs of generation at each site. Other inputs will include the resource exploration and confirmation costs described above, and the cost of connecting to the transmission system (using input from other members of the PPREAT team) and typical unit costs for power plant and gathering system (we will use $1,500 per kW installed). These costs will be expressed as the total costs associated with the minimum and most-likely generation level at each site, and the unit development cost ($ per kW installed) for the two possible generation levels.

Deliverables:
1.3.9a Total and Normalized Development Cost Database

Task 1.3.10 Final Project Report
The goal of this task is to prepare a Final Project Report.

The Contractor shall:
- Prepare a Final Report for this project in accordance with the process described in Project 0.6.

Deliverables
1.3.10a – Final Report Outline for the New Geothermal Site Identification and Qualification Project
1.3.10b – Draft Final Report for the New Geothermal Site Identification and Qualification Project
1.3.10.c – Final Report for the Geothermal Wind Site Identification and Qualification Project

Key Personnel
None

Key Subcontractors
Dr. Subir Sanyal, President, GeothermEx, Inc.

Emphasis Area 2:
Increasing Affordability by Improving Existing Renewable Energy Facilities

PROBLEM STATEMENT

California's existing base of renewables could provide a critical resource for additional energy supply if sufficiently developed. The state of technology and options for deploying emerging technologies to the existing resource base are changing rapidly. Technology developers and customers lack the information required to capture critical technology improvements that could expand the use of existing renewable resources.

▪**Key Barriers**

Lack of information. In the absence of critical information on the state of the resource base, potential new pathways for developing that base go unrealized.

▪**Advancement of Science or Technology**

Careful evaluation of the state's geothermal resource base will reveal new development pathways for the state's existing renewable resource base. In 1999, geothermal, biomass and wind technologies provided over 24,000 GWhrs of power for California.

EMPHASIS AREA GOALS AND PERFORMANCE OBJECTIVES

Identify new pathways for boosting production from existing geothermal, wind, and biomass facilities. Bring these resources within relative cost-competitiveness within 5, 10, and 15-year timeframes.

For supplementary detail on area goals and performance objectives, see each Project Work Statement (below).

PROJECT LIST

This emphasis area's work scope involves the following technical project:

Project 2.1 Existing Geothermal Facility Improvements (Geothermex)
PPREAT will assess the prospects of improving the output of each of the 43 existing geothermal facilities in California, including consideration of improving access to the geothermal resources as well as improving the design and operation of the power plants.

PROJECT 2.1: Existing Geothermal Facility Improvements

Project Objectives:

The objective of this project is to assess the prospects of improving the resource supply and surface facilities at each of the 43 operating geothermal power plants in California (see Table 1). The goal of these improvements will be to increase the performance and reliability, or increase the generation capacity, of each power plant.

Table 1. Operating Geothermal Power Plants in California

Geothermal Field	County	Power Plant	Operator	Capacity, MW (Gross)
1. The Geysers	Sonoma and Lake	McCabe (Units 5 & 6)	Calpine Corporation	110
2. The Geysers	Sonoma and Lake	Ridge Lane (Units 7 & 8)	Calpine Corporation	110
3. The Geysers	Sonoma and Lake	Fumarole (Units 9 & 10)	Calpine Corporation	110
4. The Geysers	Sonoma and Lake	Eagle Rock (Unit 11)	Calpine Corporation	110
5. The Geysers	Sonoma and Lake	Cobb Creek (Unit 12)	Calpine Corporation	110
6. The Geysers	Sonoma and Lake	Big Geysers (Unit 13)	Calpine Corporation	137
7. The Geysers	Sonoma and Lake	Sulphur Springs (Unit 14)	Calpine Corporation	114
8. The Geysers	Sonoma and Lake	Lake View (Unit 17)	Calpine Corporation	119
9. The Geysers	Sonoma and Lake	The contractor1 & 2		110
10. The Geysers	Sonoma and Lake	Socrates (Unit 18)	Calpine Corporation	119
11. The Geysers	Sonoma and Lake	Sonoma (SMUDGEO)	Calpine Corporation	72
12. The Geysers	Sonoma and Lake	Calistoga	Calpine Corporation	80
13. The Geysers	Sonoma and Lake	Quicksilver (Unit 16)	Calpine Corporation	119
14. The Geysers	Sonoma and Lake	Grant (Unit 20)	Calpine Corporation	119

15. The Geysers	Sonoma and Lake	The contractor 3 & 4		110
16. The Geysers	Sonoma and Lake	Bear Canyon	Calpine Corporation	20
17. The Geysers	Sonoma and Lake	West Ford Flat	Calpine Corporation	27
18. The Geysers	Sonoma and Lake	Aidlin	Calpine Corporation	20
19. Salton Sea	Imperial	Vulcan	CalEnergy	34
20. Salton Sea	Imperial	Del Ranch (Hoch)	CalEnergy	38
21. Salton Sea	Imperial	Elmore	CalEnergy	38
22. Salton Sea	Imperial	Leathers	CalEnergy	38
23. Salton Sea	Imperial	Unit I	CalEnergy	10
24. Salton Sea	Imperial	Unit II	CalEnergy	20
25. Salton Sea	Imperial	Unit III	CalEnergy	50
26. Salton Sea	Imperial	Unit IV	CalEnergy	40
27. Salton Sea	Imperial	Unit V	CalEnergy	49
28. Salton Sea	Imperial	Vulcan/Hoch Turboexpander	CalEnergy	10
29. Coso	Inyo	Navy I	Caithness LLC	90
30. Coso	Inyo	Navy II	Caithness LLC	90
31. Coso	Inyo	BLM	Caithness LLC	90
32. Mammoth-Pacific	Mono	G1	Covanta Energy Corporation	7
33. Mammoth-Pacific	Mono	G2	Covanta Energy Corporation	17
34. Mammoth-Pacific	Mono	G3	Covanta Energy Corporation	19
35. Heber	Imperial	SIGC	Covanta Energy Corporation	47
36. Heber	Imperial	HGC	Covanta Energy Corporation	47

37. East Mesa	Imperial	Ormesa I	Florida Power & Light	24
38. East Mesa	Imperial	Ormesa II	Florida Power & Light	16.5
39. East Mesa	Imperial	Ormesa IE	Florida Power & Light	8
40. East Mesa	Imperial	Ormesa IH	Florida Power & Light	6.5
41. East Mesa	Imperial	GEM	Florida Power & Light	50.4
42. Amedee	Lassen	Amedee	TGP/USEC	1.6
43. Wendel	Lassen	Wineagle	Wineagle Development	0.7

Prior Research

GeothermEx will leverage prior work to the fullest extent possible (consistent with confidentiality agreements), including the work conducted to date by various government agencies (USGS, USDOE and others), academic or research institutions (such as the Electric Power Research Institute), and GeothermEx in its role as consultant to developers, utilities, government agencies and research institutions. Over the past three decades, GeothermEx has been privileged to review each of the existing geothermal power projects in California. In addition, GeothermEx has assisted numerous field developers and utilities worldwide in improving the performance, reliability and generation capacity of geothermal power projects. In many instances, we have found that comparisons between projects can yield insights that are not obvious from the perspective of operations at particular projects. GeothermEx's prior research and worldwide, hand-on experience in similar assessments will allow a timely and realistic deliverable to be developed.

Baseline Conditions

The existing level generation for each operating geothermal plant would define its baseline condition. Therefore, the total additional generation that can be achieved from all 43 existing geothermal power plants in California based on the proposed improvements can be considered a direct measure of success in achieving our goal.

Project Goals

It is anticipated that this project will result in a well-considered and practical set of improvements in resource supply and/or surface facilities that could lead to extra generation from many of the existing power plants for a unit cost below that of developing a new geothermal power project. This should induce the field operators to consider these improvements, if they have not considered them already, and thereby increase the prospects for extra generation capacity from the existing fields. This outcome is realistic because the developers would prefer to invest in improving an existing facility rather than engaging in exploring and developing a new geothermal site.

Assuming a successful project, within 5 years of completion of this project, an overall increase in generation on the order of 10% may be achieved from the existing facilities, followed by another 10% over the following 5 years. Given the existing plants' total capacity of 2,400 MW, a 240 MW increase in capacity in 5 years and a total increase of 480 MW within 10 years appear reasonable. We do not believe that further capacity improvements of existing plants will be likely after 10 years, as the plants would be significantly aged by that time.

Performance Metrics

The objective in this task is to increase the amount of geothermal utilization in California that is achievable without any exploration or new development risk. As such, the success of this project may be judged by the interest and commitment shown by the operators of power plants in the proposed improvements, and the actual increase in generation achieved from the existing plants within the next few years.

Project Work Plans

This project will consist of reviewing potential improvements to the resource supply and power generation aspects of all operating geothermal projects in California (see Table 1). From this review, the Contractor will prepare a list of specific, practical steps that can be taken to improve the performance, reliability and capacity of existing projects through modification, optimization and augmentation of the facilities and operations.

Task List:
Task 2.1.1: Gather available technical information and conduct field inspection.
Task 2.1.2: Identify potential improvements in resource supply
Task 2.1.3: Identify potential improvements in surface facilities
Task 2.1.4: Final Project Report

Task 2.1.1: Gather available technical information and conduct field inspection
The goal of this task is to solicit cooperation of the private operators and collect the information required to develop methods of increasing the output from existing geothermal power generating facilities in California.

The Contractor shall:

- Collect published data and information from GeothermEx's non-proprietary project files. Conduct plant site visits, physical inspections and discussions with geothermal operators. Compile data that developers are willing to make available on well locations, well characteristics, well performance history, production/injection practices, the nature and disposition of surface facilities (gathering system, power plant and injection facilities) and generation history to be used as input to the following tasks.

- Prepare a Well Characteristic and Power Generation Database. This database will include information on well characteristics and power generation aspects of each of the 43 existing geothermal power generating facilities and their associated wellfields.

Deliverables:

2.1.1a – Well Characteristic and Power Generation Database

Task 2.1.2: Identify potential improvements in resource supply

The goal of this task is to identify specific, practical methods available to increase output via resource supply improvements, and estimate the costs and benefits of undertaking each of these improvements for each of the 43 existing geothermal power plants.

The Contractor shall:

- Determine ways to improve the resource supply to the power plant based on a review of the well data collected, site inspection and discussion with the operators under the previous task. Methods of improvement to be considered will include wellfield modifications (*e.g.*, well workovers or deepening, improvements in well design, drilling additional wells, testing idle wells, or shutting in selected existing wells), and improvement in fluid handling and injection practices (*e.g.*, pump operation, separator efficiency, scaling and corrosion control, optimizing pressure support via injection, etc.) All potential improvements will take into consideration any downstream effect on the power plant (*e.g.*, fluid handling capacity, temperature limitations, etc.). The approximate costs of undertaking each improvement and the anticipated increase in generation in each case will be estimated.

  We believe significant opportunities exist for improving resource supply to existing plants. For example, at The Geysers field, Calpine and the contractor both have substantially improved their steam supply by bringing treated municipal effluent from the City of Clear Lake to the field through a pipeline and injecting it into the geothermal reservoir.

- Prepare a Resource Supply Improvement Report. This report shall include a list of technically feasible and practical methods to improve the resource supply for each of the 43 existing geothermal power facilities in California, and the anticipated costs and benefits for each improvement. Report will indicate any areas of information that are lacking due to non-cooperation of geothermal owners/operators.

Deliverables:

2.1.2a Resource Supply Improvement Report

Task 2.1.3: Identify potential improvements in surface facilities
The goal of this task is to identify available methods to increase output via improvements in the surface facilities that will enhance the performance, reliability and capacity of each plant, and determine the approximate costs and benefits associated with each of these improvements for each of the 43 operating geothermal power plants in California.

The Contractor shall:
- Determine how surface facilities (downstream of wellheads) can be improved to obtain better performance or reliability of generation, or increase in generation from the plant based on a review of the power plant data collected, site inspection and discussion with the operators. The means of improvement to be considered include: additional flash stages, addition of bottoming-cycles, optimized gas handling through a combination of gas ejectors and vacuum pumps, improvement in condenser and cooling towers, etc. Estimates will be made of the approximate costs of each improvement and the consequent generation increase anticipated from the improvement.

  We believe significant opportunities also exist for improving the surface facilities. For example, at several existing projects, improvements in steam separation, pipeline configuration and power plant modification have increased generation.

- Prepare a Technically Feasible Surface Facility Improvement Report. This report shall include a list of technically feasible improvements in surface facilities (downstream of wellheads) that can lead to improvement in power plant performance, reliability or increased generation, and estimates of the costs and benefits of such improvements. This report shall also indicate if any areas of information are lacking due to non-cooperation of geothermal owners/operators.

Deliverables:
2.1.3a Technically Feasible Surface Facility Improvement Report

Task 2.1.4 Final Project Report
The goal of this task is to prepare a Final Project Report.

The Contractor shall:
- Prepare a Final Report for this project in accordance with the process described in Project 0.6.

Deliverables
2.1.4a – Final Report Outline for the Existing Geothermal Facility Improvements Project
2.1.4b – Draft Final Report for the Existing Geothermal Facility Improvements Project
2.1.4.c – Final Report for the Existing Geothermal Facility Improvements Project

Key Personnel:
None

Key Subcontractors:
Dr. Subir Sanyal, President, GeothermEx, Inc.

Emphasis Area 3:
Expanding Affordability and Diversity Using Renewable Distributed Generation

PROBLEM STATEMENT

Renewable distributed resources may provide a variety of options for adding to system resource diversity while providing significant transmission and distribution benefits. Utility planners lack information for identifying areas where distributed renewable resources make the most sense. In addition, the economics of distributed resources, particularly photovoltaic, could be improved through additional technical analysis for options to bring new system designs into the market.

- **Key Barriers**

Utility system characteristics that may or may not be amenable to deployment of distributed resources are currently poorly understood. To the extent that resources could be deployed, additional research is required to validate consumer-friendly options for deploying distributed technologies.

- **Advancement of Science or Technology**

New understanding of system characteristics that can support use of distributed resources. New product presentation approaches that facilitate customer use and integration of distributed technologies.

EMPHASIS AREA GOALS AND PERFORMANCE OBJECTIVES

Boost technical knowledge and understanding of system modeling characteristics that can support use of renewable distributed resources. Identify options for deploying distributed biomass renewable resource systems.

PROJECT LIST

This emphasis area's work scope involves the following technical projects:

Project 3.1 Distributed Generation Assessment (E3)
The objectives of this project are to identify the best locations for distributed generation in local utility distribution systems, including reliability impacts in the analysis, and to assess the impact of load growth and generator uncertainty on the results.

Project 3.2 Biomass Distributed Generation Valuation Analysis and Project Development for Public Utility Service Territories (McNeil Technologies)
The purpose of this project is to pursue the targeted development and deployment of small modular biomass systems for distributed generation applications within the service territories of at least two public power utilities.

PROJECT 3.1: DISTRIBUTED GENERATION ASSESSMENT

Project Objectives

The objectives of the project are to (1) identify the best locations for distributed renewable generation (DG) in a local Utility Distribution Company (UDC) system, (2) include reliability impacts in the analysis, (3) assess the impact of load growth and generator performance uncertainty on the results.

The analysis will focus on four distribution systems including systems for the City of Palo Alto Utilities (CPAU), the City of Alameda as well as two others among the PPREAT member utilities. The overall objective is to accelerate the deployment of renewable energy systems in a distributed generation mode by fully accounting for all benefits.

Contractor will identify at least three potential locations in each system. Reliability impacts will be expressed using estimated incremental changes to expected unserved energy (EUE). Reliability financial value will be expressed using both direct utility distribution company (UDC) cost savings and incremental customer value-of-service (VOS) estimates.

This project includes both distribution engineering and economic analysis components. Energy and Environmental Economics, Inc. (E3) will complete the economic analysis and act as lead subcontractor, and Electrotek Concepts will complete the engineering analysis as subcontractor to E3.

Prior Research

Detailed screening studies for large T&D systems have identified several elements of value that distributed generation can provide. These include capital deferral, reduced losses, reduced O&M costs, and risk reduction. These features focus on cost reduction to the wires company or an integrated utility. Although it has been postulated that distributed renewable generation can provide enhanced reliability, very little in the way of quantitative analysis has been completed to include the reliability impact in DG evaluation. This research builds upon this body of work.

The core contributions of this research:

- Analyzes local system impacts and benefits that accrue directly to a municipal UDC in a localized network;
- Expands the evaluation methodology to evaluate the impacts on local system reliability, including value to both the customers and the UDC;
- Incorporates load growth and generator system performance uncertainty as reflected in weather assumptions.

Baseline Conditions

Analytical tools have been developed and are available for screening distributed generation technologies as potential substitutes for identified T&D projects, or for screening existing T&D system expansion plans to identify high-cost and therefore high-value areas. Very few utilities in the U.S. have endeavored to apply these tools to a complete system study, or even local planning areas. The baseline of knowledge is scant and largely unquantified, although individual distribution system planners tend to have a good intuitive feel for where distribution system costs are high or low.

Up until now, reliability problems in the electric power systems have been dominated by equipment failures, weather-related incidents, and other mishaps. Rolling blackouts are new to California, caused by demand-supply imbalances rather than random events. Renewable energy systems, even intermittent ones, can achieve high availability during the hours that supply constraints are greatest (usually afternoon hours), have very low forced outage rates, and are not encumbered with air quality permitting issues as are fossil fuel combustion technologies. An appropriately diversified arrangement of renewable technologies can provide reliability equivalent to the more conventional small-scale electric power systems. A quantitative assessment of the potential local reliability gains from locally sited distributed generation is needed.

A large element of value provided by DG that has been identified in the literature is flexibility, whose value is usually enhanced when uncertainty is explicitly included in the analysis. Both load growth forecasts and renewable generation technology performance are affected strongly by weather assumptions, and this element of uncertainty can readily be incorporated into engineering and economic analysis to fully account for this added contribution.

The key measure of success of this project is establishing an understanding of the merits of distributed renewable generation in distribution systems in general, embodied in the comprehensive application to four example distribution systems.

Project Goals

Successful completion of this research will result in reduced overall system costs, enhanced local reliability, and increased resource diversity. The key anticipated outcome is an established and verified methodology and readily accessible tools for rapid assessment of distributed renewable technologies that can be applied to any distribution network.

Key issues that have hampered the development or commercialization of the identified tools and associated services to date are general unfamiliarity with distributed generation, nurtured by decades of T&D experience focused on utility solutions, lack of comprehensive and transparent tools for analysis, and overworked distribution planning staff. This research aims to break the logjam by providing a useable approach that brings insight, not just analysis.

Specific goals of this project in the five-year, ten-year, and fifteen-year timeframe are:

- Within five-years this project aims to make available a comprehensive and carefully thought-out approach for evaluating the local distribution systems for the best placement of renewable generation resources.
- Within ten-years this approach will be refined by member and other utilities to become standard industry practice.
- Within fifteen-years this standard practice will have been in place long enough to improve efficiency in distribution systems state- and nation-wide. This will lead to increased opportunities for renewable generation because of the higher value they receive as well as the decrease in costs of utility delivery systems.

The contribution this project can make in promoting renewable distributed generation is difficult to estimate in terms of increased megawatts of capacity installed. However, it is potentially very large once a number of utilities adopt a standard practice for estimating the value on the local distribution system.

Performance Metrics

Performance metrics that represent a quantifiable or measurable result from this project work include:

- Timely reports and presentations.
- Successful identification of value reflected by feeder. The analysis may find that there are many, or possibly few cost-effective distributed generation opportunities.
- Work completed on time and under budget.
- Results and work quality to the satisfaction of the distribution company, Technical Advisors and the Commission.

Project Work Plans

The core tasks are (1) economic and engineering analysis, (2) reliability evaluation, and (3) uncertainty analysis. No technological products for mass manufacture are planned for this research. However, the basic methodology and computer tools should prove valuable to all members of the PPREAT group, and to distribution system companies throughout California. These basic models and algorithms already exist as a part of the team's unique set of tools to bring to bear on this problem. The thrust of the research is the comprehensive application of these tools at the distribution system level. The subtasks described below are arranged to develop the understanding and insight for the public good, guided by experience in conducting such analysis for private clients.

Each task will be applied to each of four participating PPREAT member utility distribution systems. In the case of the utilities that are relatively small, such as the City of Palo Alto, and the City of Alameda the entire distribution system will be the most appropriate scope of analysis. For larger utility members, an appropriate portion of the system will be identified for detailed study based on a site visit, economic analysis of local T&D costs, and discussions with local distribution planners from the members.

Task List:
Task 3.1.1 Initial Data Request/Collection
Task 3.1.2 Load and Expansion Plan Analysis
Task 3.1.3 Reliability Analysis
Task 3.1.4 Uncertainty Analysis
Task 3.1.5 Final Project Report

Task 3.1.1: Initial Data Request/Collection
The goal of this task is to establish baseline data for this project.

The Contractor shall:

- Identify data sources.
- Establish a method to organize the data.
- Gather the data.
- Prepare a Baseline Data Report that fully documents the work performed in this task.

Deliverables:
3.1.1a – Baseline Data Report

Task 3.1.2: Load & Expansion Plan Analysis
The goal of this task is to identify the most promising sites and technologies for distributed generation based on distribution system engineering and economic analysis.

The Contractor shall:

- Estimate area- and time-specific marginal costs for the distribution system. The costing methodology shall follow the "best practices" approach described by K. Knapp, et. al. at the NARUC conference in November 2000.

- Analyze the area- and time-specific predicted technical performance and economics of wind, solar flat plate, solar concentrator, and fuel cell generators for the feeders in the distribution system. Conventional internal combustion engine technology and microturbines will be included as reference points. Performance shall be based on typical meteorological year data from National Oceanic and Atmospheric Administration (NOAA), or suitable substitute data at the discretion of member utility. Assessment of hybrid systems may be included at the discretion of the member utility, but is not included in the budgetary estimate.

- Develop a completed and validated circuit model, as well as a set of electrical simulations to identify where and when capacity constraints are reached on the distribution system, the sub-transmission system and the transmission system. This is done with a series of peak-day load flow calculations over a multi-year period. With these simulations, the project team will be able to determine the timing, magnitude and location of constraints in the system. This will allow the project team to more effectively focus on those locations and elements that need reinforcement for siting the renewable DG. Additionally, it will allow the project team to consider the sequencing of these constraints, which may allow more efficient siting and dispatching of DG.

  E3 and Electrotek will apply cutting-edge engineering and economic analysis to determine the best locations, sizes, and operating profiles for deploying DG in the distribution system. E3 will serve as project manager, with Electrotek providing engineering and technical analysis as subcontractor. This team uses power flow, short circuit, and marginal cost analysis to identify the benefits of DG in small areas. The team's power flow tools incorporate time and area dependent load characteristics, DG siting and dispatch algorithms, metering, and energy-exceeding-normal calculations that no other software vendor is currently doing. These techniques have been applied to many DG applications and capacity planning problems. The software tools that will be used for the analysis are unique in the electric utility industry and have been custom developed by Electrotek and E3. These tools are not being offered as cost-share due to concerns of intellectual property rights, but the cost-sharing equivalent of the software would be at least $100,000.

Comment: This software is not being offered to the Commission to assist in its development. Rather as cost share. Do we need IP?

- Prepare a Load and Resource Analysis Report, which shall describe the methodology, the (non-proprietary) data, the results, and recommendations. The results will include average marginal capacity costs, marginal operating costs, peak capacity allocation factors, and minimum size of distributed generation units required. The results will also include life cycle operating costs, cash flow requirements, and resource-to-load correlation coefficients.

- Conduct, a joint 3-day seminar on DG planning and application for PPREAT member utilities for up to 25 attendees. This three-day workshop presents basic distribution analysis techniques and then shows how they can be extended to support planning that includes DG under a new regulatory environment. Both existing planning tools and advanced tools are utilized. Likewise, economic analysis and load forecasting fundamentals are presented to lay the groundwork for understanding the concepts used in the overall planning framework. The same marginal costing and economic screening methods in Project 1.1 Feasibility of Interconnecting to the Pacific HVDC Intertie are presented, culminating with the decision-making process that identifies the best approach to solve a distribution system problem. The goal of the seminar will be to educate the UDC planners in how to identify the areas of highest value for DG and where it is practical from an economic and engineering perspective.

Deliverables:

3.1.2a - Letter of Notification that the circuit model is complete.
3.1.2b - Load and Resource Analysis Report
3.1.2c - Distributed Generation Planning 3-day seminar

Comment: New deliverable

Task 3.1.3 Reliability Analysis
The goal of this task is to estimate the potential reliability benefits that the technologies evaluated in Project 1.1 can provide for the distribution system.

The Contractor shall:

- Review historical reliability data for the distribution system, and estimate expected outage behavior based on (1) random outage events, and (2) supply shortages. For each location and its associated customer mix, estimate circuit expected unserved energy (EUE). For each promising technology type, estimate the change realized by implementing a distributed generation system. Estimate reliability financial value based on existing customer value-of-service survey estimates tied to the reliability index estimates. Estimate direct cost savings to the member utility due to reduced outage response.
- Prepare a Reliability Analysis Report, which shall describe the methodology, the (non-proprietary) data, and the results, and recommendations. The results will include historical reliability data, index estimates for each area with and without each technology type, and financial impact as both customer value of service and direct operating savings.

Deliverables:

3.1.3a - Reliability Analysis Report

Task 3.14 Uncertainty Analysis
The goal of this task is to include uncertainty in technology performance, load forecast and reliability estimates in the technical and financial performance estimated in the previous tasks.

The Contractor shall:

- Add "high" and "low" range estimates of technical parameters based on the best judgment of utility engineers and one-in-ten year "good" and 'bad" weather years. For each combined scenario, the financial and technical performance of each technology shall be evaluated and reported by scenario rather than as a single point estimate. Most of the effort will be focused on clarifying the core implications of the impact of uncertainty and the sensitivity to core assumptions employing a simplified analytical approach rather than on extensive probabilistic analysis.
- Prepare an Uncertainty Analysis Report, which describes the methodology, data, results, and recommendations from the analysis. Results include "worst case" and "best case" descriptions as well as quantitative measures such as value at risk.

Deliverables:

3.1.4a - Uncertainty Analysis Report
Task 3.1.5 Final Project Report
The goal of this task is to prepare a Final Project Report. This report will tie all three assessment tasks together into one coherent summary.

The Contractor shall:

- Prepare a Final Report for this project in accordance with the process described in Project 0.6.
- Prepare a Distributed Generation Assessment Presentation to complement the final report. Determine the audience, location and date for this presentation in consultation with the Commission Contract Manager. Make the presentation.

Deliverables:

3.1.5a – Final Report Outline for the Distributed Generation Assessment Project
3.1.5b – Draft Final Report for the Distributed Generation Assessment Project
3.1.5c – Final Report for the Distributed Generation Assessment Project
3.1.5d – Distributed Generation Assessment Presentation

Key Personnel:

None

Key Subcontractors:

Snuller Price, Senior Associate, Energy and Environmental Economics, Inc.

Project 3.2: Biomass Distributed Generation Valuation Analysis and Project Development for Public Utility Service Territories

The purpose of the project is to pursue the targeted development and deployment of small modular biomass systems for distributed generation (DG) applications within the service territory of public power utilities. The project will initially focus on conducting research within the territory of the Truckee Donner Public Utility District (TDPUD) as a test case. Based on those results, the analytic approach will then be modified and expanded to other public power utilities. The primary technology focus will be small, modular biomass energy generators in the following applications:

- Microgeneration – 15 – 50 kW systems deployed at load centers with net metering capability;
- Small Generation - 1-10 MW systems generating power for sale to wholesale or retail markets, either as stand-alone plants or in combination with pumped storage or other fossil fuel hybrids.

The primary fuel resource to be targeted is biomass generated from small trees removed during forest restoration and wildfire threat reduction operations. Due to the high costs associated with harvesting and transporting this material, the ability to locate biomass generation close to the supply may yield benefits to both the utility system and the public. Potential benefits include deferred or avoided T&D system upgrades, better local reliability and power quality, fuel supply diversity, improvements in air quality from reduced or avoided emissions, and the value of reducing wildfire hazards by thinning forest areas to generate biomass power.

The first step will be to conduct an in-depth examination of the potential benefits of biomass distributed generation within the TDPUD service territory. This assessment will: identify optimal sites for distributed biomass generation; specify the resources, equipment, and economic performance characteristics required of the technology; work with equipment providers to adapt their technologies and services to the site and its characteristics; characterize the economics of the project; implement a micro-scale technology demonstration project (15 – 50 kW); and help develop business and marketing data to take advantage of the public benefits and distributed generation values of the project.

As part of the project, the team will work to develop and implement a technology demonstration of a small modular biopower system. The contractor has identified Community Power Corporation as the potential technology partner for this phase of the project. Their gasification system, called the BioMax, will be installed in a distributed generation combined heat and power configuration. The system will be inter-tied with the grid and able to either export power or use it on-site. The project will a) demonstrate the ability to convert forest residue to usable electrical and thermal energy and b) provide an energy service company valuable experience in how to integrate this new distributed generation technology with the grid. A minimum 15 kW system will be demonstrated. The BioMax configuration is flexible depending on the needs of the project. It can be provided in either a stand-alone or hybrid architecture.

The analysis and tools developed in characterizing TDPUD's opportunities will also be used to assist TenderLand Power Company (a registered California energy service provider and renewable energy developer interested in biomass energy) with conducting a detailed engineering and economic feasibility study of constructing a small plant (1 - 10 MW) within the region. In conjunction with this plant, the team will evaluate the economics of adding a pumped storage or fossil fuel hybrid option to improve dispatchability, peak generating capacity and overall economic performance. A final project objective is to take the analysis tools, process, project development approach and technologies demonstrated in Year 1 and apply them to other public utilities with an interest in distributed generation and renewable energy.

This project is consistent with the PIER objective of enhancing research and development of renewable energy technologies and finding renewable energy applications that benefit California ratepayers. It is also consistent with the stated goals of the solicitation to develop renewable distributed generation technologies that can match demand profiles, defer transmission and distribution expansion, improve power quality, and enhance other public benefits such as reducing environmental impacts. By carefully examining the potential site-specific distributed generation benefits and then adapting technology and projects to them, this project will improve the load following and dispatch of modular biomass technologies, help improve their integration with utility control systems to enhance their value to utilities and consumers, and will help verify modular biomass systems in the field.

Project Objectives

The objectives of the project are to:

- Determine the appropriate performance characteristics (utility system needs, technology, size and cost) and most suitable locations for small modular biomass generators to provide high strategic value to the electricity system, while simultaneously providing high public benefits;
- Conduct a technology demonstration project in the 15 – 50 kWe range;
- Perform detailed engineering/economic studies of biomass plants in the 1 – 10 MW range; and,
- Develop data and models that can be used to document the results and apply similar techniques in other regions of the state

Technical and Economic Performance Objectives:

- Identify locations where biomass resources, new modular biomass technologies and hybrid systems with fossil fuels and pumped storage can address electricity system problems while providing public benefits, which can also serve as examples for other public utilities;
- Identify R&D, technology enhancements and project designs needed to develop modular biomass generating systems that can meet required generation performance characteristics;
- Conduct a technology demonstration project of a micro-scale technology (about 15 kW) in the TDPUD region; and,
- Document the methodology and project results such that they can be replicated in the territories of other public power utilities.

The specific, technical objectives upon which this project's success will be evaluated are:

- The ability of the models and procedures developed to identify strategic applications of biomass based DG that address problems facing Truckee Donner and other public utility electricity systems and simultaneously provide high public benefits;
- A report that identifies R&D priorities, technology enhancements and project specifications that will help distributed biomass technologies play a strategic role in meeting California's energy needs;
- The value of the information provided in a demonstration project to verify results of the model and approach, and the acceptance of the results by potential project developers; and,
- To develop a methodology that reduces the time and costs of evaluating and siting biomass energy systems in high value distributed generation applications.

Prior Research

There has been extensive prior research on modular biomass generation technologies, to the point that systems are beginning to be offered pre-commercially. However, there has been little investigation of how these systems can be deployed to optimize their value as distributed generation within a utility setting, or how the public benefits can be marketed to consumers and utilities in order to increase their value and improve their economics. Because the technologies are just beginning to be deployed, there has also been little feedback from actual deployments and marketing efforts to inform manufacturers and developers of improvements in technology, controls, or operating procedures that would enhance their value. This project would take advantage of the technology research and development that has been accomplished so far, but would extend and enhance it by seeking out and characterizing high-value applications that will enhance the technology's value to consumers, utilities, and project developers.

This project is also unique and timely because to the best of our knowledge, Community Power Corporation's BioMax system is the only distributed generation combined heat and power biopower system available in the U.S. The first BioMax was developed under the Department of Energy's Small Modular Biopower program and has recently been shipped to the Philippines where it is being installed in an unelectrified village and will provide power using coconut shells. A 12 ½ kW BioMax is currently being constructed for installation in June 2001 in California under a separate PIER project. In that project, the system will convert forest slash to heat and power for an off-grid forest regeneration complex owned by the Hoopa Valley Indian Tribe. However this project is very different in that it will be grid-connected and will focus much more extensively on improving technology, siting and design to broaden the technology's potential applications. This project represents a major departure from the Hoopa project that will advance the state-of-the-art in interconnection of this new distributed generation technology to the California grid.

Baseline Conditions

Even though there is a significant amount of biomass power generation in California, there are many biomass resources in the Truckee Donner area and other parts of California that have few productive uses. Much of the biomass in the area is a product of forest thinning and is too small or damaged for use in wood products. Other resources are mixed with urban wastes on the way to landfills. There is no market system and no demand that would support fuel brokers who could aggregate useful quantities of biomass for power generation. The public is largely unaware of the benefits of using biomass for energy, and even if they are concerned with forest health and the threat of wildfire, there are few opportunities for them to directly support solutions to these problems. Modular biomass technologies are very new to the market, and there is still much to be learned about the optimal approach to deploying and marketing them.

Project Goals

By achieving its objectives, this project will help demonstrate the economic and public benefits of using biomass resources that are largely wasted today. It will also demonstrate the value of deploying modular biomass systems strategically within the electric transmission and distribution system to enhance its benefits. The project is designed to lead to the development of a modular biomass generating plant that will demonstrate both the technology and a new marketing approach for siting systems, that other electric service providers and developers will be able to apply. There will also be analysis tools and data that the project will export to other public utilities, to begin developing similar projects in California.

Within 5 years or less the project has the potential for at least 300 MW of new generation based on resources that are known to be available. This estimate only includes resources and capacity that were previously used for biomass generation, but were taken off line for lack of competitive generating technology, and recognition of the distributed generation benefits of modular biomass generation. With improved siting to maximize distributed generation benefits and the option of deploying biomass capacity in small increments near loads and resources this project can overcome key barriers to biomass generation that have led to a decline in capacity over the last several years.

Within 5 to 10 years there is enough biomass resource and anticipated load growth to support 2000 to 3000 MW of generation in California. This demonstration of new small-scale technologies and distributed generation benefits is focused on public utility situations, but the technology is also adaptable to urban wood waste and to industrial wood wastes at small scales. While the applications in this demonstration are geared to rural areas, there are even greater distributed generation benefits in terms of addressing transmission and distribution bottlenecks and providing reliable on-site power for customers with high electricity demand in urban fringe and industrial areas.

Within 10 to 15 years this technology will be fully commercialized and widely used both nationally and internationally as a small-scale wood waste disposal technology and on-site generation option. At levels of manufacturing comparable to diesel generating systems and with a distribution and maintenance network established, this technology has the potential for 6000 to 7000 MW of generation in California alone, and tens of thousands of MW in other developed countries. There is an even larger potential market in developing countries. Aside from direct generation in the state, this technology will also generate exports and trade for California. California will be the first state to apply this technology for grid-connected applications and to develop distributed generation markets. Manufacturing and development will be strongly attracted to California, which in turn should become a primary manufacturing and distribution base for deployment in the rest of the U.S. and in overseas markets.

Performance Metrics

The key performance metrics that can be used to measure the success of the project are:

- Commission and peer acceptance of the analysis tools and methods used to characterize distributed generation opportunities and benefits of biomass generation.
- Demonstration of a small modular biomass technology in a grid-connected setting (approximate size 15 kWe). The system will generate power for the on-site load, for export back to the grid, and for a combination of on-site and grid export.
- Reduce BioMax costs of generation by 25 percent over current state of the art.
- Development of a small generating plant (1-10 MW) in size by TenderLand (pending favorable economic and technical analysis).
- Successful adaptation of modular biomass generating technology, controls and operating procedures identified during the analysis to enhance the distribution generation value of projects.
- Acceptance by consumers, TenderLand, Truckee Donner or one other public power entity of the technical, business and marketing plans for the project.
- Public recognition in newspapers and other media outlets of the public benefits produced by the project.

Task List: Technical Tasks

Task 3.2.1 - Electricity System Analysis and Identification of Potential High-Value Sites
Task 3.2.2 – Resource and Public Benefits Characterization
Task 3.2.3 – Distributed Generation Valuation of Project
Task 3.2.4 – Project Technical Feasibility and Economic Analysis
Task 3.2.5 – Micro-scale Technology Demonstration: Project Development and Engineering
Task 3.2.6 – Initiate Detailed Economic/Engineering Feasibility Studies for Medium Size Plant
Task 3.2.7 – Document Year 1 Results, Plan for Year 2 Implementation
Task 3.2.8 – Implement Micro-scale Technology Demonstration at High Value Site
Task 3.2.9 – Initiate Medium Size Plant Construction and Development (If Economically Feasible)
Task 3.2.10 – Implement Analysis in New Public Power Location and Plan Second Demonstration
Task 3.2.11 – Document Year 2 Results, Refine Focus For Year 3
Task 3.2.12 – Conduct Second Technology Demonstration Project
Task 3.2.13 – Commission and Operation of Medium Sized Plant
Task 3.2.14 – Implement Analysis in Other Public Power Districts
Task 3.2.15 – Final Project Report

Precondition

The Contractor shall:

Document the successful demonstration of Biomax technology from Community Power Corporation (CPC) at the Hoopa Valley Regeneration Complex before beginning work on Task 3.2.4. This CPC project is currently being funded through PIER contract number 500-00-029. CPC has to document energy generation, costs, emissions and other technical and economic performance at Hoopa Valley before they can demonstrate their technology at Truckee. This documentation shall discussed at the project kick-off meeting and a schedule for providing the information agreed to.

Deliverable:
Schedule for documenting Hoopa Valley results.
Documentation of Hoopa Valley results.

Comment: added task and deliverables.

Task 3.2.1 Electricity System Analysis and Identification of Potential High-Value Sites

The goal of this task is to evaluate TDPUD’s transmission/distribution system to identify areas where the system faces potential capacity or reliability problems (“hot spots”), and to compare the performance of conventional solutions to these problems with those offered by distributed biomass generation. McNeill will examine the available data and develop locations to test as potential sites for distributed generation.

<u>Objectives:</u>

- Characterize system demand profile and identify T&D hot spots that are near potential biomass resource sites.
- Compare conventional and biomass resource alternatives to resolving the local T&D issues.
- Determine characteristics for distributed generating facilities that address T&D hot spots.

Subtask 3.2.1.1 System Data Development and Analysis Objectives:

The goal of this subtask is to identify, compile and format all data sources that will be necessary for conducting the analysis of TDPUD's system.

The Contractor shall:

- Obtain latest copies of generation, transmission and reliability studies and appropriate data sets for the Truckee-Donner and surrounding areas.
- Identify major transmission, distribution lines and substations.
- Analyze the gathered data to summarize planned generation, load and capacity growth and ability of system to handle growth.
- Prepare a Description of Base Case DG Opportunities in TDPUD Report.
- Prepare a System Characteristics for TDPUD Report.

Deliverables:

3.2.1.1a - Description of Base Case DG Opportunities in TDPUD Report
3.2.1.1b - System Characteristics for TDPUD Report

Subtask 3.2.1.2 Distributed Generation Site Evaluations

The goal of this subtask is to identify sites with the highest potential distributed generation benefits, considering current and projected loads and transmission system conditions on both a typical daily and seasonal basis. Because modular biomass technology is potentially mobile, the analysis will also consider the advantages of relocating to ease access to resources, and adjust to seasonal changes in utility demand. The data developed in task 2.1.1 and 3.2.1.1 will be used in this analysis.

The Commission, other public utilities and distributed generation developers will be able to use the analysis to prioritize conventional solutions that provide the greatest economic and system reliability. Truckee-Donner and other utilities could also use the analysis of sites to test alternatives presented by different parties and to demonstrate the importance of constructing generating and transmission alternatives in particular locations that increase reliability or enhance customer service. Given the current power shortages in California, it is important for the Commission and developers to concentrate development on those locations that provide the greatest value.

<u>Objectives</u>

- In collaboration with Truckee-Donner and TenderLand determine locations with best combinations of distributed generation, public and economic benefits.
- Determine generation characteristics best suited to different locations, integrate data into GIS to facilitate future analysis, and identify alternative locations for a modular plant

The Contractor shall:

- Characterize the transmission and distribution system in terms of load growth rates, key seasonal variations, and suitability to siting and interconnection of a modular biomass generating facility over near-term, 5-year and 10-year timeframes. This will define system "hot spots."

- Develop a list of the generating characteristics that could be valuable in any given location (e.g. size of system, dispatchability, peaking requirements, baseload requirements, cost parameters, ease of operation and maintenance).

- Integrate the data, once the conditions at candidate sites are characterized into a GIS and overlaid with other public benefits data such as emissions, biomass resources, fire hazard areas, water, and natural gas. This information will be used later to prioritize the plant locations and define which ones are also located in areas where there are high potential public benefits, and compare biomass to conventional alternatives.

- Prepare a Characterization and Development Report. This report shall include two parts. First, it will have a characterization on the most promising candidate sites. Second, it will contain a description of operating characteristics and parameters required for development at each candidate site, implications for product design, manufacturing, deployment and operation of technologies.

Deliverables:

3.2.1.2a - Characterization and Development Report

Task 3.2.2 – Resource and Public Benefits Characterization

The goal of this task is to coordinate all renewable resource and public benefits data collection and analysis efforts, and ensure that all data collected in this and other project tasks are compatible and fully integrated into GIS format. The GIS will be used to identify areas where there are overlaps of system hot spots, high public benefits, and appropriate biomass resources for the generation characteristics needed in a given problem area.

Objective

- Collect local biomass resource and public benefits data and develop data layers into GIS format to facilitate analyses
- Integrate relevant project data from Task 3.2.1.1 into GIS data format
- Conduct screenings to identify locations where biomass may be used to address system hot spots and provide high public benefits

Subtask 3.2.2.1 Develop resource data and layers

The goal of this subtask is to identify, collect and format renewable resource and public benefits data, and integrate these data, and data developed under other tasks, into a uniform GIS format.

The Contractor shall:

- Identify the renewable resource and public benefits data that will be required for the project. This phase will identify the types of resources to include, the specific variables to be collected, scale needed, potential locations, and whether there are any obstacles to collecting the data.

- Develop data layers for renewable resources and public benefits analyses. Consultant will collect the following data layers for the GIS: forest thinnings, urban wood waste, landfill locations, unemployment, fire hazard index.

- Document the data used in the project so other stakeholders and interested parties may use the data and follow the methodology, to in effect create an analysis tool that other utilities will be able to use.

- Prepare GIS Layers and Underlying Data Sets based upon the information and data gathered.

- Prepare an Integration GIS Dataset. This data set will be created by integrating data from the previous tasks into the GIS data formats.

- Prepare a Metadata Report. This report shall include metadata prepared for all databases and GIS layers used in the project.

Deliverables:

3.2.2.1a - GIS Layers and Underlying Data Sets
3.2.2.1b - Integration GIS Dataset
3.2.2.1c - Metadata Report

Subtask 3.2.2.2 Conduct Characterizations and Analysis Activities

The goal of this subtask is to use GIS to identify areas where there are overlaps of system hot spots, high public benefits, and appropriate biomass resources matched with the generation characteristics required in a given T&D problem area.

The Contractor shall:

- Conduct sensitivity analyses to model the impacts of expected short-, mid- and long term technology characteristics.
- Ensure that the results of the GIS screening yield data to be used later during the more detailed project development portion of the project. The case study will verify the results of the analysis.
- Prepare a Technology Characteristics Location Map. This map will show locations that correspond to high public benefits, system hot spots and appropriate renewable resources for short-, mid-, and long-term technology characteristics.

Deliverables:

3.2.2.2a - Technology Characteristics Location Map

Task 3.2.3 Distributed Generation Valuation of Project

The purpose of this task is to collect information on the economic and technical characteristics of the candidate modular generation technologies.

Objective

- Identify and compile information on available modular biomass generating equipment operating and economic characteristics for distributed generation applications
- Evaluate the potential for delayed or replaced transmission system upgrades due to biomass generation
- Determine where renewables have a competitive advantage or significant positive externalities compared to conventional solutions to California electricity system needs

Subtask 3.2.3.1 Identify Biomass Distributed Generation Operating and Economic Characteristics

The goal of this substask is to compile data on technical and economic performance characteristics of modular biomass generating technologies for near-, mid- and long-term conditions. The focus will be on systems for the following applications:

- Microgeneration – 15 – 50 kW systems deployed at load centers with net metering
- Small Generation - 1-10 MW systems generating power for sale to wholesale or retail markets. Either as stand-alone plant or in combination with pumped hydro storage

The Contractor shall:

- Identify and finalize the relevant equipment suppliers and technology to be included in the study, and identify the operating, performance and economic characteristics to be included in the analysis.
- Develop cost characteristics per unit of generating capacity for candidate biomass technologies. A preliminary list of the cost information to be collected for renewable DG technologies includes:
    - Design/Permitting/Construction/Engineering/Contingencies
    - Capital equipment/technology costs
    - Interconnection costs
    - O&M Costs
- Prepare a Technology Report. This report will detail the results of the technical and economic characterization.

Deliverables:

3.2.3.1a - Technology Report

Subtask 3.2.3.2 Conduct Scenario Analysis for DG Applications in System Hot Spots
The goal of this subtask is to determine where a biomass facility has a competitive advantage or significant positive externalities compared to conventional solutions to California electricity system needs

The Contractor Shall:

- Conduct scenario analysis. The scenario analysis will be an iterative process whereby the impact of targeted distributed renewable generation on the electrical system is assessed.
- Integrate results of this task into the economic analysis. The most promising sites will be studied in greater detail through a case study analysis in Task 2.4. The role of the economic analysis will be to explore the biomass distributed generation option in greater detail at two specific locations.
- Prepare a Candidate Site and Technologies List. This list shall include candidate sites and technologies where biomass generation may be candidates for distributed generation applications.
- Prepare a Two Potential Locations List. This list shall include a list of two potential locations and specific biomass technologies (at the micro level and the central generator level) to be evaluated in more detail.

Deliverables:

3.2.3.2a - Candidate Site and Technologies List
3.2.3.2b - Two Potential Locations List

Task 3.2.4 Project Technical Feasibility and Economic Analysis
The overall purpose of this task is to test the results of the study for a specific case at the local level in preparation for project development. The task will verify the results of system analysis, resource analysis, and technology projections.

Objective
- Develop assumptions and a methodology for conducting the case study and economic analysis
- Conduct an economic analysis of developing each separate project, from the points of view of the developer, the utility, and the public, and comparing the costs and benefits of the most promising applications with conventional system upgrades.

Subtask 3.2.4.1 Develop Methodology and Collect Additional Data
At this stage of the analysis, the team will develop the final methodology for analyzing the demonstration projects. The goal of this subtask is to finalize an approach and methodology for conducting the study and the economic analysis and gather additional data as needed.

The Contractor shall:

- Determine a final methodology and approach for conducting the project feasibility analysis. The methodology shall address requirements for distributed generation benefits at the local level, technical analysis, and economic analysis. Included in this will be an evaluation of how public benefits will be assigned economic values, and how these will be included in the analysis and in the approach to marketing the project and its generation.
- Schedule meetings with Truckee-Donner, TenderLand and equipment suppliers to determine the availability and detail of the distribution system, equipment and interconnection requirements. If detailed load flow analyses are necessary, the contractor will recommend that utility staff study the potential distribution solutions.
- Prepare a Demonstration Project Methodology Report. This report shall include the following:
    - Description of data and methodology to be used
    - Location and technology to be evaluated
    - Additional data for use in power flow model, technical and economic analysis

Deliverables:
3.2.4.1a - Demonstration Project Methodology Report

Subtask 3.2.4.2 Economic/Financial Analysis
The goal of this subtask is to evaluate the economics of deploying the technology, from the perspective of the project developer.

The Contractor shall:

- Develop two pro-forma economic analysis models: one for the micro-scale application, and one for the central generating plant applications. Models will be user-friendly and thoroughly documented so that other utilities will be able to adopt them. The models will be structured to allow critical assumptions (e.g. discount rate, financing methods, sale price of electricity, wholesale market escalation rates, potential public benefits subsidies, etc.) to be modified easily and sensitivity analyses to be performed.
- Evaluate and document potential project financing options for the specific DG application, taking into account possible state and federal low-cost loan programs for DG and specialty "green" financing options

that may be available. Large-scale commercial or industrial DG application financing arrangements will be assessed using commercial financing structures and rates.

- Prepare an Economics of Deploying Technology Report. This report shall include the following:
  - Documentation of assumptions used in the analysis
  - Results of two pro-forma analyses (spreadsheets) for the case study
  - Economic analysis models in electronic format, with documentation, provided to the Commission Contract Manager

Deliverables:

3.2.4.2a - Economics of Deploying Technology Report

Subtask 3.2.4.3 Comparison of Distributed Generation Option with Conventional System Solutions, Including Public Benefits Assessment

The goal of this subtask is to conduct a detailed analysis of the potential system benefits to be gained if the projects are implemented.

The Contractor shall:

- Develop a methodology for estimating the impacts of DG on system reliability, capacity, deferral or avoidance of system upgrades and power quality.
- Develop a methodology for assigning economic values to public benefits that may accrue through use of renewable DG technology (e.g. what are the benefits of reducing wildfire risk if forest biomass is used for fueling a biomass plant), and determine how these benefits should be included in the analysis.
- Compare the economics of deploying a biomass plant with conventional solutions to the system problems. The comparison will be made for two scenarios: 1) a straight economic comparison of the two options from the developer and utility perspectives; and 2) including values for the public benefits that may accrue through use of the biomass technology.
- Prepare a DG v. Conventional Comparison Report. This report shall include:
  - Documentation of methodology and assumptions used
  - Results of the comparison and discussion of social, political, technical and economic implications for public power utilities and California

Deliverables:

3.2.4.3a - DG v. Conventional Comparison Report

Task 3.2.5 – Micro Scale Technology Demonstration: Project Development and Engineering
The goal of this task is to coordinate all aspects of the technology demonstration project. Taking the results and information developed under tasks 1 through 4, the team will plan a suitable demonstration project in the TDPUD area.

The project will seek to demonstrate the technology being developed by Community Power Corporation of Littleton, Colorado. The CPC technology has not been demonstrated in a grid inter-connected setting. The project will seek to document the costs, energy generation, economic performance, technical performance, emissions and other criteria associated with running the technology at a small load center.

Objectives

- Coordinate with host site, Community Power Corporation and host utility to analyze specific details of the project (host site needs, utility interconnection agreements, safety, fuel supply, operating requirements, permits, etc.)
- Conduct engineering design studies and technology modifications as needed
- Make arrangements for system procurement, financing, and installation

The Contractor shall:

- Make all arrangements to locate a host site for the demonstration project. The host site will be selected based on the results of the analyses conducted in tasks 3.2.1 through 3.2.4. McNeil will provide coordination between the host site, the utility, TenderLand and CPC.
- Work with CPC, the host utility, TenderLand and others to ensure the generator characteristics of the BioMax system match as closely as possible the high value requirements of the system. CPC will be responsible for any engineering modifications to be made to the BioMax system.
- Evaluate interconnection requirements, including, safety, equipment needs, buy-back rate, provisions for net-metering. Assist host site in obtaining required permits.
- Work with all parties to determine how the system and technology demonstration program will be financed. Due to the unproven nature of the technology and its high initial costs, it is anticipated that some Commission funds will be used to assist with design, project engineering, system procurement, installation and on-going monitoring.
- Prepare Final Agreements for the technology demonstration signed by all parties.
- Prepare a Pre-Demonstration Summary Report. This report shall document the development efforts leading up to the demonstration

Deliverables:

3.2.5a - Final Agreements
3.2.5b - Pre-Demonstration Summary Report

Task 3.2.6 Initiate Detailed Economic/Engineering Feasibility Studies of Medium Size Plant
The goal of this task is to conduct a detailed feasibility analysis of constructing a biomass plant that will primarily sell power either to the retail or wholesale markets. Based on the needs of the system and the results of the initial economic analysis, the size of the plant and the potential hybrid options will already be known. This phase of the project will involve refining the economic analysis, developing specific financing options, initiating preliminary, fuel supply contracts and conducting detailed engineering studies on the expected performance of the project, including an analysis of the hybrid options. The goal is to allow TenderLand to get to a "go/no-go" decision point on the project.

Objective

- Initiate detailed economic and financial analysis of the 1-10 MW option
- Finalize technology configurations to be used for the project
- Develop sufficient data for TenderLand to reach a "go/no-go" decision
- If a "go" decision is reached, initiate design, financing and construction activities

The Contractor shall:

- Develop estimates of fuel requirements and costs, capital equipment costs, interconnection equipment and permitting engineering costs, performance characteristics and revenue projections for the biomass power plant specifications and assumptions developed above.
- Develop several system financing and power marketing scenarios under which parameters the system economics will be evaluated.
- Based on the economic and engineering analyses in the above activities, develop a recommendation as to the viability of the technology and potential site-specific factors that are likely to impact TenderLand's go/no-go decision to construct the plant.
- Recommend technology modifications, financing conditions, and other factors that can improve the economics of the plant from a project developer perspective.
- Prepare a Feasibility Summary Report. This report shall explain the rationale for either the "go" or "no-go" decision using the results of the analysis and an explanation of key financial and performance drivers that affect the decision. This report shall not divulge any information that is proprietary to TenderLand.
- Prepare an Analytical Method Summary Report. This report shall include a summary of the analytical methods and results to be included in the year-end report.

Deliverables:

3.2.6a - Feasibility Summary Report
3.2.6b - Analytical Method Summary Report

Task 3.2.7 – Document Year 1 Results, Plan for Year 2 Implementation
The goal of this task is to document the entire Year 1 efforts of the project. The final report will also make recommendations as to the major findings, lessons learned, how future analyses in other public power utilities can be streamlined, and what the priority actions for Year 2 of the project should be.

Objective

- Create a First Year Report and package the analytical tools developed in the first year so they can be used by public power utilities, biomass energy developers, energy service providers, equipment manufacturers and policy makers to replicate the project in other locations.

The Contractor shall:

- Prepare a First Year Report Outline. The Commission Contract Manager shall provide the suggested format for this outline. The report will summarize and discuss the economic, technical, social and political implications of whether biomass distributed technologies are suited to address electrical system technical issues, while simultaneously providing public benefits. It will also document the results of the study, discuss R&D implications for biomass energy technologies and provide suggestions as to what steps the Commission should take next.
- Submit the outline to the Commission Contract Manager for review and acceptance. Once agreement on the outline has been reached, it shall be submitted to the Commission Contract Manager within 5 working days. The Commission Contract Manager shall provide written acceptance within 5 working days of receipt.
- Prepare the Draft First Year Report in accordance with the approved outline.
- Submit the draft report to the Commission Contract Manager for review and comment. The Commission Contract Manager will provide comments within 20 working days of receipt. If the Commission Contract Manager takes reasonable issue with the format or thoroughness of the draft Report, the Contractor and the Commission Contract Manager shall in good faith discuss such issues and the Contractor shall take actions to address the Commission Contract Manager's concerns. Once agreement on the draft report has been reached, the Commission Contract Manager shall provide written acceptance within 5 working days.
- Submit the Final First Year Report to the Commission Contract Manager within 10 working days.
- Prepare a Presentation of Findings that shall be presented to Commission, PPREAT and at a DG conference.

Deliverables:

3.2.7a – First Year Report Outline
3.2.7b – Draft First Year Report
3.2.7c – Final First Year Report
3.2.7d - Presentation of Findings

Task 3.2.8 – Implement Micro-scale Technology Demonstration at High Value Site

The goal of this task is to implement the technology demonstration program, as it was designed in Task 3.2.5. The team will ensure that the system is designed, constructed and installed on site. The performance of the system under various configurations will be evaluated for one year.

<u>Objective</u>

- Conduct the technology demonstration project
- Monitor and evaluate the technical and economic performance of the system in various configurations
- Disseminate results of the demonstration to other public power agencies and stakeholders
- Arrange for the demonstration project to be toured and used for public outreach and education

The Contractor shall:

- Develop a system installation punch list to ensure system safety and reliability, O&M protocols and system testing requirements.
- Coordinate with the project host site property owners and the interconnecting utility to ensure that the project schedule will enable continuity of power supplies for the host and system reliability and safety for the utility.
- Relocate and install CPC system at operating site, with the assistance of CPC technical staff.
- Coordinate with host site property owners to develop and implement daily monitoring plan and remote monitoring (as is feasible) program; train on-site staff for monitoring and data reporting – variables to be monitored will include electricity generation, system reliability, labor costs, fuel processing costs, replacement part costs.

- Coordinate with TDPUD and the host location to develop a plan for conducting ad hoc on-site tours of the facility and develop and produce summary and technical information to be distributed via the tours.
- Prepare an Installation, Maintenance and Performance Data Set. This data set shall include installation and maintenance data, performance data and information developed during the initial start-up and monitoring phases of the demonstration.
- Prepare a Stakeholder and Feedback Report. This report shall include a list of all prospective stakeholder contact information and feedback from site tours and the showcase tour.
- Prepare a Systems Performance Report. This report shall include resulting analysis and summary recommendations and conclusions related to the system performance with an emphasis on results that impact this technology's potential for DG deployment in other areas, to be included with the year-end report for this project phase.

Deliverables:

3.2.8a - Installation, Maintenance and Performance Data Set
3.2.8b - Stakeholder and Feedback Report
3.2.8c - Systems Performance Report

Task 3.2.9 – Initiate Construction and Development of Medium Size Plant (If Economically Feasible)
If the detailed analyses in Phase I appear promising, it will be the goal of TenderLand to begin construction of a plant in the 1-10 MW range. Design, engineering and construction costs will be the responsibility of TenderLand.

Objective

- Initiate final pre-construction activities associated with building a plant
- Move project from the planning to the construction stage
- Host a ground breaking ceremony
- Initiate construction

The Contractor Shall:

- Determine the system size and information on site characteristics such as fuel availability, costs and processing requirements; interconnection requirements (transmission capacity availability and costs, interconnection voltage requirements, transformer capacity and relaying/switching needs for the proposed generation technology configuration), and other potential contingency items that can affect the results of engineering and economic pre-feasibility results.
- Solicit bids for project design, construction, training and O&M options for the biomass plant for qualified engineering design and construction firms. Select the best-value contractor.
- Develop project-financing packages that meet economic parameters.
- Host a groundbreaking ceremony for high-level Commission and DOE officials, the Governor of California, utility representatives and trade associations, and initiate project construction following the ceremony.
- Prepare a Status of Construction Report summarizing the status of construction to be provided by the end of Year 2.
- Prepare a Media Package for the ground-breaking ceremony, to be distributed prior to the ceremony for TV and radio coverage and after for journal and print media

Deliverables:

3.2.9a - Status of Construction Report
3.2.9b - Media Package

Task 3.2.10 – Implement Analysis in New Public Power Location and Plan Second Demonstration
The goal of this task is to repeat the analysis portion of the Phase I effort in the utility service territory of another interested public power agency. The effort will seek to identify additional opportunities for biomass distributed generation using the models and methods developed in the first Phase.

The Contractor shall:

- Conduct DG analyses in a second public power agency's service territory, repeating the approach and methodology developed under tasks 3.2.1 through 3.2.4. As appropriate, modify and streamline the process so that the potential high-value, high public benefit sites can be identified sooner and for less cost then the Phase I effort. Any lessons learned will be incorporated so that the procedure may become more efficient. In general, the following five steps will occur:
- Power System Analysis and Identification of Potential High-Value Sites
- Resource and Public Benefits Characterization
- Biomass Project Distributed Generation Valuation Analysis
- Economic Analysis of Biomass Energy Technology Distributed Generation Benefits
- Initiate planning for a second technology demonstration site, perhaps using a different technology than the first demonstration.
- Prepare a Results and Identification Report. The report shall include the following:
    - Results of analysis in a second public power service territory
    - Identification of two new potential locations for high value biomass DG – one for on-site generation and the second for centralized generation for sale to retail or wholesale markets

Deliverables:

3.2.10a - Results and Identification Report

Task 3.2.11 – Document Year 2 Results, Refine Focus For Year 3
The goal of this task is to document the results of Year 2 and plan for the final year's efforts.

<u>Objective</u>

- Create a Second Year Report documenting the results of Year 2 activities
- Refine the approach for Year 3 activities.

The Contractor shall:

- Prepare a Second Year Report Outline. The Commission Contract Manager shall provide the suggested format for this outline.
- Submit the outline to the Commission Contract Manager for review and acceptance. Once agreement on the outline has been reached, it shall be submitted to the Commission Contract Manager within 5 working days. The Commission Contract Manager shall provide written acceptance within 5 working days of receipt.
- Prepare the Draft Second Year Report in accordance with the approved outline.
- Submit the draft report to the Commission Contract Manager for review and comment. The Commission Contract Manager will provide comments within 20 working days of receipt. If the Commission Contract Manager takes reasonable issue with the format or thoroughness of the draft Report, the Contractor and the Commission Contract Manager shall in good faith discuss such issues and the Contractor shall take actions to address the Commission Contract Manager's concerns. Once agreement on the draft report has been reached, the Commission Contract Manager shall provide written acceptance within 5 working days.
- Submit the Final Second Year Report to the Commission Contract Manager within 10 working days.
- Prepare a Presentation of Findings that shall be presented to Commission, PPREAT and at a DG conference.

Deliverables:

3.2.11a – First Year Report Outline
3.2.11b – Draft First Year Report
3.2.11c – Final First Year Report
3.2.11d - Presentation of Findings

Task 3.2.12 – Conduct Second Technology Demonstration Project
The goal of this task is to conduct another technology demonstration project of the small modular biomass technology. Preferably, a different technology than the one being used in the first demonstration project will be utilized. The equipment cost of this second demonstration will be left to the private sector or to other sources of cost-shared funding, to be determined.

<u>Objective</u>

- Identify a suitable location for the technology demonstration project
- Implement a second 15-50 kW (approximate) on-site demonstration project
- Compare the costs and technical performance of the second project with the first

The Contractor shall:

- Conduct similar activities to those described for the small modular biomass project above, but for a second location. Specific details of the actual steps to be followed will be based on the results of the first demonstration project. Lessons learned will be incorporated into the activities.
- Conduct a second technology demonstration project.
- Monitor and gather data on the second demo project, so that performance may be compared with the first demonstration project.

- Prepare a Second Demonstration Project Results Report. Results of the second demonstration project will be included in the Year 3 Final Report

Deliverables:

3.2.12a - Second Demonstration Project Results Report

Task 3.2.13 – Commission and Operation of Medium Sized Plant

The goal of this task is to see the successful commercial operation of the medium sized plant. TenderLand will conduct the primary work on this task.

Objective

- Commission and begin operation of the centralized generation plant that was analyzed in Year 1 and for which construction started in Year 2 (if the project has actually gone ahead).

The Contractor shall:

- Prepare a Medium Sized Plant Status Report. This report shall include a brief overview of the status of the plant, its history and initial performance, if appropriate. Summary information on the plant to be included in the Year 3 Report

Deliverables:

3.2.13a - Medium Sized Plant Status Report

Task 3.2.14 – Implement Analysis in Other Public Power Districts

The goal of this task is to implement the DG valuation analysis in the service territory of a third public power utility. The focus during Year 3 will be to apply the lessons learned from Years 1 and 2 and work with utility staff, developers and equipment providers to rapidly identify and evaluate potential candidate locations.

Objective

- Identify new high value DG site locations
- Streamline and refine the analysis methodology
- Provide outreach so that others may learn the approach and methodology and use the tools developed for siting and deployment
- Identify two new specific projects that can be developed by the private sector

The Contractor shall:

- Replicate, as necessary, Tasks 3.2.1 through 3.2.4 in another public power service territory. The approach will be to provide outreach, training and guidance to utility personnel and project developers in the methods and approach. The contractor will tailor and document the analysis approach so that other stakeholders get trained in the methods and may identify potential opportunities directly.
- Prepare an Additional Site Candidate List, which will include a list of additional sites suitable for biomass DG.

Deliverables:

3.2.14a - Additional Site Candidate List

Task 3.2.15 – Final Project Report

The goal of this task is to prepare a Final Project Report. This report will tie all three assessment tasks together into one coherent summary.

The Contractor shall:

- Prepare a Final Report for this project in accordance with the process described in Project 0.6.

- Make analysis tools developed by the project available to other developers and utilities to use in developing distributed generation applications. A copy of these tools and a list of the recipients shall be provided to the Commission Contract Manager.

Deliverables:

3.2.15a – Final Report Outline for the Biomass Distributed Generation Valuation Analysis and Project Development for Public Utility Service Territories Project
3.2.15b – Draft Final Report for the Biomass Distributed Generation Valuation Analysis and Project Development for Public Utility Service Territories Project
3.2.15c – Final Report for the Biomass Distributed Generation Valuation Analysis and Project Development for Public Utility Service Territories Project
3.2.15d – Copy of the analysis tools and a list of the recipients.

Comment: These deliverables have new names.

Key Personnel:

None

Key Subcontractors:

Kevin DeGroat, McNeil Technologies

Emphasis Area 4:
Developing Renewable Technologies for Tomorrow's Electricity System

PROBLEM STATEMENT

Today's range of usable renewable technologies is limited by the state of current science and technology related to renewables. Targeted work with a series of emerging technologies -- utilizing wave, biomass, solar thermal, and photovoltaic resources -- can help expand the universe of renewables ready for use by system planners.

- **Key Barriers**

Even relatively mature renewable technologies can make great strides in technology improvements. Technologies farther from commercial readiness lack the support required to demonstrate market potential and evaluate critical issues for resolution prior to commercial readiness.

- **Advancement of Science or Technology**

PPREAT work in this area will expand the total knowledge base about renewable resources as it relates to each of the technologies under evaluation by the group.

EMPHASIS AREA GOALS AND PERFORMANCE OBJECTIVES

PPREAT aims to two or more of these emerging technologies into cost-competitiveness with other resource options within a ten-year timeframe. For supplementary detail on area goals and performance objectives, see each Project Work Statement (below)

PROJECT LIST

This emphasis area's work scope involves the following technical projects:

Project 4.1 Solar Thermal Parabolic Trough Powerplant (Duke Solar)
PPREAT will carry out a pre-feasibility evaluation of advanced solar thermal trough power plants, with an emphasis on site selection and evaluation near the HVDC intertie.

Project 4.2 Hybrid Bio-fuel/Natural Gas (Stirling)
This project is focused on the development of bio-fueled and natural gas cofired modular Stirling engine systems for distributed and on-site generation applications.

Project 4.3 Energy Storage for Renewable Generation (Electranix)
PPREAT research will address how the application of energy storage capability might increase the economic effectiveness and value of wind and PV renewable energy sources. A particular focus will be placed on potential interactions with the HVDC intertie project, but the methods used will also apply to other possible development locations.

PROJECT 4.1: Solar Thermal Parabolic Trough Powerplant

Project Goals and Objectives

The goal of this project is to carry out a pre-feasibility evaluation of advanced solar thermal power plants leading to an aggregated Power Purchase Agreement (PPA) from a group of California municipal utility companies (Muni's). The plants, to be developed as IPP projects subsequent to the completion of this effort, are to consist of a series of advanced parabolic trough solar thermal power facilities at California sites totaling 1000 MWe, with emphasis on supply to the Pacific HVDC intertie. The future plants would be built in time-sequenced phases, each consisting of a single or complex of plants from 50 to 200 MW in size. A key objective of this evaluation will be to determine the optimum approach for development.

The technical objectives are to:

(1) evaluate advanced solar field and system configuration concepts suitable for imminent commercial implementation,

(2) determine the required power capacities and production schedule to contribute to aggregated system demand requirements using dispatchable solar thermal power plants,

(3) identify the optimal and alternative sites for the selected solar thermal power plant facilities, and

(4) in particular, evaluate the prospect of interconnection to the Pacific HVDC intertie in the Owens Valley/Mojave Desert corridor.

The economic/business objectives are to:

(1) review available system benefit charges, subsidies, production credits, green power premiums, and other renewable incentives,

(2) evaluate all siting requirements and establish appropriate financial assumptions,

(3) perform initial cost, performance, and economic analyses of promising solar thermal power plant options and configurations,

(4) establish schedule for plant design, construction and operation,

(5) explore various business and ownership models, and

(6) develop, working with the Muni's, a draft PPA for implementation.

Prior Research

The parabolic trough is the solar technology of choice for these projects due to its maturity based on extensive field experience in commercial facilities. Earlier models of parabolic troughs have been commercially demonstrated in 354 MW of commercial installations that have produced over 8700 GWH during the past 13 years of plant lifetime.

The 30-80 MWe SEGS plants are located in the California Mojave Desert and were constructed from 1984 through 1990. In those projects the parabolic trough solar collector fields supply steam to Rankine cycle turbine systems.

Advanced trough systems require commercial implementation. In the late 1990's an extensive development program to improve performance and reduce O&M costs was carried out by KJC Operating Co. and Sandia National Laboratory. Partially due to this program, the solar plants at Kramer Junction have experienced their peak performance during the last several years, with a very high availability of the solar fields and steadily increasing performance records on a daily and annual basis. The projects in this emphasis area will benefit from these achievements as well as new advanced developments in receiver performance and thermal storage systems.

Advanced Concepts:

Trough collectors: In keeping with their commitment to further improve performance and reduce costs in the solar steam generation system, the SEGS plant operating companies in California, Duke Solar, and others have developed plans for further advances in the collector design and solar field system. Duke Solar is currently developing a lighter structural concept, and investigating non-imaging optics for trough design. It is planned that the solar field installed in this project will, for the first time, combine the innovations developed since the installation of the last LUZ solar field in 1990 at SEGS IX. Measures will be taken in the design, manufacture and procurement phases to facilitate integration of the latest advances in a single improved solar field design.

Integrated solar/power block operation: Efficient operation of a solar power plant requires that all the energy that can be collected by the solar field be utilized to the full extent possible by the power block. Two areas of concern are morning startup and summer peak solar conditions. The SEGS plants in California lack the most optimum design in this regard, and innovative steps will be taken here to improve this aspect of operation. Experience in the operating plants has shown that careful design is required to coordinate steam generation by the solar field and warm-up of the turbine, particularly with regard to introducing superheated steam to the turbine. The turbine warm-up criteria are quite strict in order to stay within acceptable limits to avoid metal fatigue under cyclic stress conditions. The need is to match the solar field to this requirement without wasting solar field energy.

The problem in summer peak operation is of a different nature. If the solar field is sized for full-load operation of the plant starting in the late spring, then there will be frequent midday periods in summer when a portion of the solar field must be defocused because its energy cannot be used. In these projects, the solar field sizing will be optimized to minimize this problem and to provide the most cost-effective match of the solar field with the power block under the design operating scenario.

Thermal energy storage: Significant progress has also been made in the development of thermal storage technologies for parabolic trough power plants. The addition of thermal storage allows solar plants to shift the electric generation to better support peak power demand periods. This effort will evaluate the economics of using state-of-the-art thermal storage technologies to allow dispatching solar power to meet winter evening peak loads. This helps to increase the economic value of power generated without requiring fossil backup.

Integration of solar field with natural gas combined cycle plant: A trough plant configuration of considerable current interest is known as the Integrated Solar Combined Cycle System (ISCCS), which is based on a conventional combined cycle design. In the conventional configuration, the exhaust heat from the combustion turbine generates steam in a heat recovery steam generator (HRSG) to drive a steam turbine connected to a generator, with supplemental heat input from the solar field to increase the steam to the steam turbine. The ISCCS, however, combines mature gas turbine/steam turbine technology with mature solar parabolic trough technology. This approach offers a potentially more cost effective and thermodynamically efficient method to utilize solar thermal energy to produce electricity compared to the use of solar energy with a conventional boiler fired (Rankine) cycle plant.

A combined cycle plant operates on the Brayton cycle, and modern combined cycle plants can achieve thermal efficiencies over 55%. This compares to a fossil-fired project where fuel is fired in a boiler to produce steam to drive a Rankine cycle plant at an efficiency on the order of 40%. Solar-produced steam can be used more effectively in a combined cycle, and the heat rate of the combined cycle plant may be improved by the use of solar.

In most conventional combined cycle plants the steam turbine has about half the megawatt capacity of the combustion turbine. In the ISCCS concept, in which the solar field supplements the steam generation function, the steam turbine capacity needs to be larger (e.g., an incremental increase in capacity from 25% up to 100%). The selection of this incremental capacity is an important consideration in ISCCS design. Crucial issues in the effective utilization of parabolic trough solar fields in combination with combined cycle plants are the ability to achieve a significant reduction in global emissions, the effective annual heat rate of the combined system, and the cost impact on plant output. Certain secondary but nonetheless important operational factors are also beneficial. The ISCCS approach will be considered for this application in our pre-feasibility evaluations.

Other programs: To the best of our knowledge, the work in this project is not being duplicated by any other ongoing program in the U.S. or internationally.

Baseline Conditions

Technically, the baseline technology consists of the LS-2 and LS-3 trough collector models used in the SEGS plants, and the hybrid solar/natural gas Rankine cycle configuration of those plants. From a business standpoint, the standard offer No.'s 2 and 4 established by the California PUC in the 1980's constitute the baseline PPA.

Projected Outcomes

This project itself will deliver new site selection data for California for large scale solar thermal power plants near the Pacific HVDC intertie or elsewhere, propose a construction plan for a sequence of plants up to a total of 1000 MW, show the performance and cost reductions that may be derived from a next series of projects, develop a new PPA model for such plants, and propose financial and business options that fit current needs.

Further development of parabolic trough power plants continues to be hindered by concerns over high plant investment costs in one-of-a-kind or small-scale projects, and the inability to demonstrate the technology gains due to the lack of new plant construction. Having shown good performance and reliability in the previous series of SEGS facilities, a new series of plants is required to show the improved performance and reduced costs that will come from standardized engineering, large plant capacities, high manufacturing production rates, and multi-plant procurement and construction. The dramatic impact of a large 1000 MW project plan on both investment and operating costs, as well as performance, cannot be overemphasized

The power plants to be built based on the PPA's for the proposed aggregated market are expected to show an increase in performance of 10-15% over current metrics that will result in lower emissions by the same percentage and achieve markedly lower electricity costs.

The following table shows our expectations of reduced investment costs, increased performance and lower electricity costs for the 1000 MW series of projects compared to values for the later SEGS plants. Investment costs of these plants are expected to reduce by 30% over the duration of the total project, and electricity costs even more due to gains in performance and reductions in O&M costs.

Project Start	Constructed Capacity	Capital cost $/kW	Annual solar efficiency, %	Electricity cost cents/kWh
SEGS	354 MW	2800	12	14.0
2002	200 MW	2200	14	11.0
2003	200	2100	14.5	9.4
2004	200	2050	15	8.6
2005	400	1990	15	7.7-8.2

Subsequent Business Plan

Following the completion of a PPA with one or more municipals, project development leading up to a possible 1000 MWe of solar power plants will commence. Successful financial closing will depend on many factors, though the most critical will assuredly be the terms of the PPA. While exact scheduling or project configuration is not possible to predict at this time without taking the initial steps outlined in this contract, for planning purposes we are projecting the construction of approximately 100 MWe per year over 10 years. Again, for planning purposes we are basing our projections on SEGS-type (Rankine cycle steam turbine) solar plants, constructed in 200-MWe increments at a site. Both project development and plant construction can be markedly accelerated if more plants are co-located at a single site. This not only simplifies the site development and construction process, it also lessens the costs and simplifies the organization required for operation and maintenance (O&M) after start-up. The Figure shown below illustrates this sequence of 200-MWe increments.

With regard to business issues, a number of very important benefits can be realized with a total project of this size. Economies of scale will be seen in many areas, namely standardization of some aspects of engineering design, mass procurement of materials, mass production of solar field components, and large-scale construction. There is no doubt that additional experience in all aspects of the implementation will improve the cost-effectiveness of the projects.

Financing arrangements will be part of this picture. Many possibilities and options exist in this regard. For example, aggregation of the debt financing could result in significant cost reduction. All avenues of solar renewal energy project incentives will be fully explored. The project financing will either be handled by Duke Energy itself, or possibly through the involvement of a major project financing company. Duke Solar will work out these details and mechanisms in parallel with the work leading to the PPA that is within the scope of this contract.

Future Years

Even further gains can be achieved in subsequent years based on this start. Estimates of parabolic trough solar thermal plant projections over a 15-year window are shown in the next Table.

Year	Capital cost $/kW	Annual solar efficiency, %	Electricity cost cents/kWh
SEGS	2800	12	14.0
+5	1990	15	7.7
+10	1800	16	6.0
+15	1600	16.5	5.5

Future implementation of the proposed power plants will enhance renewable energy resource diversity by furthering the entry of a new solar technology to the market, one that complements wind and PV due to its crucial characteristic of dispatchability by virtue of hybrid operation or thermal storage. Affordability will also be enhanced by bringing on line the lowest cost solar energy resource at capacities large enough to define the average cost of solar power in California.

It is very difficult, if not impossible, to project the level of plant capacity that can be installed beyond the 10-year framework covered in our business plan. A development of this size will open the door for larger-scale developments in the future, limited only by the ability to expand the infrastructure for manufacturing, construction and project development. Other companies interested in developing large-scale solar thermal power plants will assuredly benefit from the Duke Solar developments. Furthermore, Duke Solar is pursuing developments in other areas of the U.S. and internationally, and the synergism between this plan and other projects is sure to result in more cost-effective development in California. At a minimum, we project that another 1000 MWe would be developed and constructed by Duke Solar over the next 5 years (that is, during the 10-15 year interval).

Task List:

Task 4.1.1 Seminars and Site Visits
Task 4.1.2 Electricity Demand Requirements – Collect Data and assess needs
Task 4.1.3 Site selection and evaluation
Task 4.1.4 Technical pre-feasibility evaluations
Task 4.1.5 Determine Site Requirements
Task 4.1.6 Business Models
Task 4.1.7 Incentive Reports
Task 4.1.8 Financial Feasibility Study
Task 4.1.9 Draft PPA
Task 4.1.10 Final Project Report

Task 4.1.1: Seminars and Site Visits

The goal of this task is to conduct four regional seminars for the participating California municipal utilities on CSP to raise awareness and to conduct a joint visit to the SEGS plants.

The Contractor shall:

- Work with PPREAT to determine where to hold the seminars, determine what information the muni's need to receive, prepare the presentations (including a power point presentation), identify host municipals, conduct the seminars and plan and hold the site visit to the SEGS plant.

Deliverables:

4.1.1a - Power Point Presentation

Task 4.1.2: Electricity Demand Requirements – Collect Data and assess needs
The goal of this task is to collect data on electricity demand patterns, time-of-use pricing, and match of solar output to demand. Assess dispatchability needs.

The Contractor shall:

- Prepare a Solar Thermal Plant Assessment Report that summarizes assessment of solar thermal plant match to demand, including value of dispatchability options (hybrid operation or thermal storage.

Deliverables:
4.1.2a - Solar Thermal Plant Assessment Report

Task 4.1.3: Site selection and evaluation
The goal of this task is to perform a site selection evaluation in regions of mutual interest that would include access to land, natural gas, water and electricity distribution, with special attention to the HVDC grid.

The Contractor shall:

- Prepare a Potential Site Ranking Report that ranks the highest potential sites for this project.

Deliverables:
4.1.3a - Potential Site Ranking Report

Task 4.1.4: Technical pre-feasibility evaluations
The goal of this task is to perform technical pre-feasibility study, including performance and engineering.

The Contractor shall:

- Prepare a Technical Option Ranking Report, which shall report the ranking of technical options at selected sites.

Deliverables:
4.1.4a - Technical Option Ranking Report

Task 4.1.5: Determine Site Requirements
The goal of this task is to determine current Commission and Federal agency project and environmental approval, permit requirements, emission offsets, and other requirements.

The Contractor shall:
- Prepare a Required Permits Report that summarizes all of the permitting requirements, lays out the actions necessary to secure them, and proposes a realistic schedule.

Deliverables:
4.1.5a - Required Permits Report

Task 4.1.6: Business Models
The goal of this task is to explore different business and ownership models for the plants.

The Contractor shall:

- Prepare a Business Model Report that describes the different business models, presents their pros and cons and recommends a ranked set of options for the muni's for review and comment.

Deliverables:
4.1.6a - Business Model Report

Task 4.1.7: Incentive Reports
The goal of this task is to review current subsidies, production credits, green premiums, etc. available to the proposed solar thermal power projects.

The Contractor shall:

- Prepare an Incentives Report that includes information on available and desirable incentives.

Deliverables:
4.1.7a - Incentives Report

Task 4.1.8: Financial Feasibility Study
The goal of this task is to perform an initial economic analysis (pre-feasibility study) of a series of CSP hybrid options at different sites. The result will be to rank the potential sites and projects on a financial basis.

The Contractor shall:

- Prepare an Economic Analysis Report. This report shall include information on the economics of CSP power plants at different sites and a recommendation where the site should be, if economics were the determining factor.

Deliverables:
4.1.8a – Economic Analysis Report

Task 4.1.9: Draft PPA
The goal of this task is to develop a draft model PPA and its key terms to be used for the aggregated municipal market.

The Contractor shall:

- Prepare a Draft Model PPA. The draft will include its key terms to be used for the aggregated municipal market and for discussion with municipals.

Deliverables:
4.1.9a - Draft Model PPA

Task 4.1.10 – Final Project Report
The goal of this task is to prepare a Final Project Report.

The Contractor shall:

- Prepare a Final Report for this project in accordance with the process described in Project 0.6.

Deliverables:
4.1.10a – Final Report Outline for the Solar Thermal Parabolic Trough Powerplant Project
4.1.10b – Draft Final Report for the Solar Thermal Parabolic Trough Powerplant Project
4.1.10c – Final Report for the Solar Thermal Parabolic Trough Powerplant Project

Key Personnel:
None

Key Subcontractors:
Gilbert Cohen, VP of Engineering, Duke Solar

Project 4.2: Hybrid Bio-Fuel/Natural Gas

Project Objectives

This project is focused on developing bio-fueled and natural gas-fired modular Stirling engine systems for distributed and on-site generation use as a new source of renewable energy ("green") power and energy supply. The developed systems will respond to an increasing need for distributed and on-site power generation resulting from an increase in electricity demand, inadequate generation and congestion of existing electricity distribution systems. The systems will also respond to regulatory changes with respect to increased environmental control of municipal (both utility and water districts), agricultural and industrial landfill and wastewater treatment facilities and the deregulation and/or re-regulation of US retail electricity supply. We believe there is a considerable market for use of this technology and systems at municipal utility district (electric and water) landfill and wastewater sites.

Using the external combustion cycle of the Stirling design is expected to result in superior engine reliability, fuel source flexibility, high efficiency and reduced emissions compared with alternatives. To reduce development cycle expenses and time, we intend to use existing proven components where feasible. We expect existing components and systems will be available for all major sub-systems. The system design will be modular permitting control that is responsive to market and load changes and provides the ability to more accurately design systems.

The Stirling Energy Systems team (SES) is well positioned to support the technical and economic objectives associated with the "Bio-fuel and natural gas Stirling Engine (90) kilowatt Demonstration Project." SES currently staffs and maintains an office in Huntington Beach, California at the SES/Boeing Solar Test site where the SES (25) KW Solar Stirling system is located. See attached files for more information, photos and staff CV's. For additional information , please see www.stirlingenergy.com. In addition to SES' regional presence (SES) will continue to use its teaming partners to support the projects technical and economic objectives. SES is teamed with Boeing, Kochums, Siemens, NASA, the United States Department of Energy (DoE) and Vestas in the development and implementation of its solar Dish Stirling Program. For this project, SES will team with the following support sub-contractors: Black & Veatch Corporation, Handshake Energy LLC, Merit Engineering and, where appropriate, Boeing and Kockums.

Comment: Preexisting IP?

The objectives of this project are to complete research and development for a demonstration prototype dual-fueled, bio and natural gas, Stirling engine(s) generator set with a generating capacity of approximately (90) kilowatts capable of operating in accordance with CA and Federal interconnection and emissions standards; and further to establish parameters (technical and economic) for successful commercialization of the dual fuel prototype(s).

Preferred fuels are expected to be wastewater treatment plant flare off-gas and landfill gas. For solid waste and high sulfur-content biogas fuels, 2-stage burners may be required. We expect to be able to use MSW RDF (refuse-derived fuel), landfill and waste water treatment plant flare off-gas. For larger output systems, gas processing may be required or economically advantageous. At a minimum, the fuels that will be tested include, landfill and natural gas.

Under this Program, SES will provide research and development (R&D) to work towards achieving the Projected Outcomes as set forth below, including efforts to:

1. Perform Research and Development (R&D) of a bio-fueled and natural gas Stirling genset for distributed and on-site power generation applications.
2. Research available external burner sections capable of operating on available bio-fuels within program design and economic parameters.
3. Prepare technical standards for a natural gas and biomass Stirling genset distributed generation product.
4. Complete market, distribution and financial model analysis for distributed generation product.
5. Solicit interest from PPREAT members for utilization and host participation of a demonstration unit.

The SES team will provide weekly status reports for monitoring project performance regarding stated objectives and success of action items to date. In addition, SES will establish an on-line site for Internet access of project information. The site will be utilized for posting summary reports, documents, schedules and data regarding project status and performance.

Prior Research

SES has engaged in some previous activity with respect to prototype engine development with Kockums for chemical fuels (natural gas and bio) and others for solid waste fuel. This contemplated work herein is additive and not redundant. SES has also performed initial commercial and emissions analysis, again additive not redundant.

Baseline Conditions

One of the initial tasks will be to establish current efficiency, emissions and costs parameter for existing and forecasted alternative and competing technologies. See Projected Outcomes for target results.

Projected Outcomes

The projected outcome of this research effort is:

- The development of a modified external burner section capable of operating on available bio-fuels within program design and economic parameters.
- Integration of the modified external burner section with a Stirling engine with a generating capacity of approximately 90 kilowatts for use as an on-site distribution generation demonstration prototype unit.
- Field Testing of prototype/demonstration unit
- Establish economic model for markets conditions with respect to price competitiveness (as compared to other green options, incentive driven, blended green offerings). Low production price target is $1500 per installed kWh, $400 mass production scale. These numbers are conservatively consistent with the NASA Mod II report for natural gas fired systems.
- Financial and business model for product offering in California market (5 year, 10, year) roll out. Goal is to achieve results capable of attracting a strategic co-investor, production vendors and distributors. This would avoid additional substantial funding by PIER.
- Establish teaming agreements for product/systems with PPREAT members and partners, prospective co-investors, vendors and distributors.
- Projected Alpha commercial unit has a target date of 12/31/02.
- Projected installed units approximately (10) units and (1) MW by 12/31/03
- Projected (10) MW installed at year (5)
- Projected (50) MW installed by year (10)
- Projected (250) MW installed by year (15)

Performance Metrics

SES will provide quantifiable and measurable performance metrics in order to measure the results of this project in accordance with generally accepted standard for government projects of this type. Such metrics will include; weekly on-line status reports, plans, drawings and specifications of the modified dual fuel system, test results and data associated with the commercialization of the Stirling engine/power plant.

In addition, as a component of this research effort, we will provide a business model with financial projections for the application and utilization of the demonstration unit in California. Such report will identify production thresholds and the relative impact on product pricing and market acceptability. The report will clearly state technical and economic assumptions and include 5, 10 and 15 year models. The plan is also to educate PPREAT members to the benefits associated with the prototype unit and further to design a program for PPREAT that addresses the issue of aggregating load, expanding the use of renewable sources, increasing affordability (through economies of scale) and application of the Stirling "green" product in California.

Project Work Plans

Task List:

Task 4.2.1	Research, testing and development of modified external burner section
Task 4.2.2	Business Plan – economic model and product application for the California market
Task 4.2.3	PPREAT Reach out – Campaign
Task 4.2.4	Final Project Report

Task 4.2.1 - Research, testing and development of modified external burner section

The goal of this task is to develop, build, and test a modified external burner section capable of operating at "acceptable" conditions and further able to be integrated into a (90) kilowatt Stirling distributed on-site generation unit.

"Acceptable" in this context means establishing design, production and operating parameters during the implementation of the contemplated R&D effort to:

- Meet all code requirements including: (1) CA and Federal interconnection standards; (2) CA and Federal emissions standards; and (3) all other applicable mechanical, civil and electrical code requirements
- Satisfy system economic viability parameters including: (1) target unit pricing (Low production price target is $1500 per installed kW, $400 mass production scale); (2) design life-cycle reliability of 20+ years with proper maintenance at reasonable O&M costs; (3) achieving expected output efficiency in the 28-34% range, depending on engine choice.
- Be capable of networking multiple units to operate as part of a facility or grid compatible system utilizing energy management control, metering, or SCADA systems to match load, fuel capacity, safety, dispatchability, maintenance, emission and reporting requirements.
- Be capable to recover thermal/heat output to improve system efficiencies by operating in cogeneration cycle.

The Contractor shall:

- Research, build, modify, design and test prototype bio-fuel burner section in lab. The section design shall be designed in such a manner to be a component of the (SES) renewable power plant system and further can be networked together in multiple increments of (90) kW (scalability) for future load conditions and requirements.

- Prepare Preliminary External Burner Design that shall include plans and specifications for preliminary design of external burner

- Prepare a Prototype Database that shall include prototype testing data, product modification data, operating data.

- Prepare a Demonstration Report that shall include demonstration data, specifications, pictures, and mark-up, specs.

- Prepare a Letter of Notification that a prototype burner Stirling (90) kilowatt system has been manufactured and is ready for viewing and use.

Deliverables:
- 4.2.1a - Preliminary External Burner Design
- 4.2.1b - Prototype Database
- 4.2.1c - Demonstration Report
- 4.2.1d - Letter of Notification

Task 4.2.2 - Business Plan – economic model and product application for the California market

The goal of this task is to provide a business plan for the (90) kilowatt demonstration unit for the California marketplace.

The Contractor shall:

- Research the market and provide a business plan for the demonstration unit in the California market. The plan will include economic projects, market assumptions and a 5, 10 and 15 year business plan for roll out and production of the prototype unit (California and national plan). SES will use their best efforts to avoid redundancy regarding prior research of others, including Kockums. SES is committed not to do redundant work, to the best of their knowledge.

- Prepare a Nonproprietary Prior Work Report summarizing SES's nonproprietary prior work, and if possible the related prior work of others from publicly available, non-proprietary information.

Deliverables:
- 4.2.2a - Draft business plan for review
- 4.2.2b - Final business plan (California and national markets)
- 4.2.2c - Plan for commercialization of prototype unit
- 4.2.2d - Nonproprietary Prior Work Report

Task 4.2.3 - PPREAT Reach out – Campaign
The goal of this task is to contact and educate PPREAT members to the benefits of the (90) kilowatt prototype unit.

The Contractor Shall:

- Contact PPREAT members and partners and provide information and data with respect to the prototype unit and the associated benefits of the Stirling system. In addition, SES will solicit interest from this group for participating in the initial commercialization of the demonstration unit.

- Prepare a Tech Transfer Package which shall include the following:
  - Power Point Presentation for PPREAT members and Partners
  - PPREAT Program – Fact Sheet
  - Market Reach Program – PPREAT members-partners

Deliverables:

- 4.2.3a - Tech Transfer Package

Task 4.2.4 Final Project Report
The goal of this task is to prepare a Final Project Report.

The Contractor Shall:

- Prepare a Final Report for this project in accordance with the process described in Project 0.6.

Deliverables:

- 4.2.4a – Final Report Outline for the Hybrid Bio-Fuel/Natural Gas Project
- 4.2.4b – Draft Final Report for the Hybrid Bio-Fuel/Natural Gas Project
- 4.2.4.c – Final Report for the Hybrid Bio-Fuel/Natural Gas Project

Key Personnel:
None

Key Subcontractors:
David Olson, Stirling Energy Systems, Inc

Project 4.3: Energy Storage for Renewable Generation

Project Objectives

As a complement to the Feasibility of Interconnecting Pacific HVDC Intertie project, this project addresses how the application of energy storage capability might increase the economic effectiveness of wind and photovoltaic (PV) renewable energy sources. The most effective use of wind/PV energy is achieved when suitable energy storage capability is available. Interconnection to the Pacific HVDC Intertie or AC transmission system will provide opportunities to utilize regional hydro resources for energy storage, but in addition, the emerging technologies of energy storage (regenerative fuel cells, batteries, superconducting magnetic energy storage) can be applied.

In the simplest of terms, when the wind is not blowing and the sun is not shining, wind/PV energy cannot be generated. However, if the energy has been previously stored, it can be released to meet the load demand at the most desirable moment.

The project will examine use of energy storage for stabilizing price and availability of energy generated from these sources. Any economic benefits will be determined and assessed as a measure to see if indeed the cost effectiveness of wind/PV energy is improved with optimum use of energy storage.

In specific terms, the project will look at:

- The available realistic energy storage options and quantify them in terms of their cost effectiveness. Those energy storage options that are not cost effective will be discarded.
- The energy storage options that will be considered will include but not be limited to the following:
    - Existing hydroelectric resources
    - Batteries
    - Superconducting magnetic energy storage
    - Regenerative fuel cells
- Sizing and location of new energy storage facilities if they are cost effective.
- Possible hydroelectric generating companies that might be amenable to a contract for energy storage.

This is an exploratory project that might be considered as a first stage. Because of the new technologies involved, a second stage can be more clearly defined when this project is completed, and the new energy storage technologies are better understood.

Prior Research

Large wind farm installations generally deliver energy and displace use of non-renewable energy. In most cases other sources of energy and power supply are necessary in the event the wind is not blowing. This usually results in installing twice the generating capacity for firm supply of electricity.

To date, research and development of energy storage systems for renewables has been somewhat limited. Effort has been made in a few installations, to coordinate the energy generated from wind turbines with available hydroelectric energy sources. As long as the water storage facilities are not spilling and there is capacity in the reservoirs, energy storage is possible. If the resources in this regard are favorable, utilizing energy storage from hydroelectric generators and reservoirs are an attractive combination for optimizing wind generation.

The same benefits can apply to PV installations.

Energy storage for wind and PV installations requires relatively large energy storage capacity to be useful. As a consequence, there has not been a realistic and reasonably priced energy storage option available except for hydroelectric storage as discussed above. It is a subject that has received too little attention in the past. In Denmark where wind turbine capacity exceeds 30% of total installed generating capacity, energy storage is taken very seriously. They have very little hydroelectricity to take advantage of in this regard. The technology is advancing rapidly. For example, the new technology of regenerative fuel cells (www.regenesys.com) appears promising for large energy storage applications.

There is great value in exploring how wind energy developed near the California – Nevada border region could be more effectively applied if used in conjunction with energy storage. The hydroelectric option will be explored by first concentrating on the relatively close WAPA Central Valley Project, to contracting energy storage further afield from BPA or BC Hydro.

PPREAT will be seeking large-scale development of renewable energy projects through aggregated demand by its public power utility members. Energy storage could maximize effective use of renewable energy projects. Large-scale renewable energy projects will prove more competitive against large-scale fossil fuel resource projects and may be made more efficient if reasonably priced energy storage capability is available.

Electranix Corporation will be separately working with Eltra of Denmark (the Transmission Operator of Western Denmark) on a 10 MW demonstration application of a regenerative fuel cell in association with a new offshore wind farm. Another demonstration plant is being built in Tennessee by the Tennessee Valley Authority. Knowledge gained from these developments will be applied to this project.

Baseline Conditions

For this project to be considered a success, economic effectiveness must be demonstrated with overall minimum impact on the environment. More specifically, the following baseline conditions must apply:

- Renewable energy resources must be identified for which energy storage capability can be applied.
- The energy storage must enhance the cost effectiveness and operation of the new renewable energy. Determination of cost effectiveness will require full exploration of cost benefits that might be allocated to energy storage for the renewable resources.
- The project must be environmentally friendly. In addition to making it possible for renewable energy sources to be developed in relatively remote locations, the storage of this energy near the California load must be environmentally acceptable.
- Existing wind generators in general do not have specific energy storage facilities they can use to deliver the energy they have generated when it is needed most. The results of this project impact these existing intermittent generators in that the procedure to determine rating, capacity, location and cost effectiveness of energy storage can then be applied to their case.

Projected Outcomes

The projected outcome from the completion of this feasibility study and the development of energy storage for renewable energy sources is:

- The new renewable energy sources will be more effectively used in the California market. The energy would be available when it is needed most and will more efficiently add to the diversity of energy sources available to the State.
- A corresponding amount of less environmentally friendly energy will be displaced.
- Energy prices in California could be stabilized due to additional generation. Non-volatile energy pricing will be possible from the identified renewable energy sources, with a stabilizing effect on overall electric energy pricing in California.
- Added energy from the development of renewable resources with energy storage will increase the reliability of energy supply to the California power system.
- This program will provide a technical assessment on the energy storage options for the renewable energy resources identified for future development in the California -Nevada border regions.
- Economic viability will also be determined for the various energy storage options and recommendations for future developments will be made. Such recommendations cannot be forthcoming at this stage unless this project is completed.

- A profitable case made by this project for use of energy storage in conjunction with renewable energy sources will open up the way for a schedule of development as laid out below.

A realistic schedule of development over the next 15 years is as follows:

Year 1 to 3: Feasibility assessment as a result of this contract. This is to be undertaken in conjunction with the related project under Area 1, Feasibility of Interconnecting Pacific HVDC Intertie. The energy storage study would start six months after of this related project has commenced to allow for time for the first project to gain momentum.

Year 4 to 5: If the energy storage is to be achieved by contract with one or more hydroelectric generating companies, negotiations for the necessary contracts would be undertaken and finalized, providing the development for the renewable energy sources is underway. The only limitation to having hydroelectric energy storage in place when the wind energy becomes available is getting the contracts and operating procedures in place.

If alternative energy storage facilities are to be used instead, then owners and/or investors must be assembled, the site(s) located (preferably near the load), and environmental impact study processes and permitting must be initiated. The project's engineering consultant must be selected and the transmission planning study commenced that leads to the specification of equipment.

Year 6 to 7: With permitting in place and for the option where alternative energy storage facilities are to be used instead of contracts with hydroelectric generators, prepare specifications for the energy storage facility and associated substation. Go through the process of selecting the energy storage equipment supplier. Select equipment suppliers for the construction of the associated substation.

Year 8 to 10: Commissioning of the new energy storage facilities and commencement of commercial operation.

Year 11 to 15: Commercial operation.

Performance Metrics

The following performance indices can be used to determine the effectiveness of the recommended interconnection:

- How much new renewable energy generation is available for use by customers at the times it is needed most?
- What is the expected return on investment for the recommended energy storage option? This will be a main indicator of the project feasibility.
- What environmental impact does the energy storage option have? This will not include an environmental impact study, but a general environmental observation on the facilities and their impacts will be made.
- Investors (including investor owned utilities) may benefit from the investment opportunities that result from the development of new energy storage systems.

Project Work Plans

Task List:

Task 4.3.1	Development of an Optimizing Model for Energy Storage of Wind/PV Generation
Task 4.3.2	Assemble Data for the Energy Storage Model
Task 4.3.3	Evaluate Energy Storage Options
Task 4.3.4	Prepare Final Project Report

Task 4.3.1: Development of an Optimizing Model for Energy Storage of Wind/PV Generation

The goal of this task is to develop a computer model of energy storage that could be applied for optimizing its application with the specific wind energy sites under consideration for development near the California –

Nevada border. Such a model will help determine MW rating and energy capacity to best fit the wind energy sites under consideration. In addition, the model will evaluate the improvement to energy utilization when selective release of energy from storage is possible.

The Contractor Shall:

- Prepare a Modeling Package that can be applied for optimization of energy storage facilities associated with wind/PV energy sources. Documentation on the use of the optimization model will also be included.

  The model requires data pertaining to load duration information of the load being served, the generation duration expectation over a year, energy pricing, weekly load curves over a season or year and information on possible hydroelectric resources that might offer energy storage capacity.

  This task will utilize the results from a monitoring and characterization project for wind systems (a project funded by NREL and contracted to Electrotek Concepts). Detailed monitoring of both electrical characteristics and environmental data has been conducted to provide data that can be used to develop better models for system impact studies.

  Additional system impact studies were performed as part of a project prepared for the Utility Wind Interest Group (UWIG), entitled "Characterizing the Impacts of Significant Wind Generation Facilities on Bulk Power System Operations Planning," dated January 2000. This project addresses the impact of large wind generation resources on power system operations and scheduling functions. It does not address energy storage directly, but does form a good starting point for the system studies to be performed in this task. The UWIG project is listed as a cost-shared contribution in this contract.

  With representative input data, the model will be used to evaluate various options for energy storage for the application at hand. Commercially available software will be used which have built-in functions required for the modeling (Matlab, Mathcad, PSCAD, etc).

  To accurately characterize storage capacity, this task will also include a review of any existing storage capabilities for baseload plants and the integration of renewable storage capacity with existing capacity.

Deliverables:

- 4.3.1a - Modeling Package. (The deliverables will be available at no charge for all members of PPREAT.)

Task 4.3.2: Assemble Data for the Energy Storage Model

The goal of this task is to gather the essential input data necessary to assess the cost effectiveness of adding energy storage capability when large wind generation is being developed.

The Contractor Shall:

- Prepare an Energy Storage Evaluation and Development Progress Report. The report shall include the data for the energy storage evaluation to be applied to the energy storage model. This report shall also include a review of the existing storage developments in the United States, such as pumped hydro.

  In order for the energy storage optimization model developed in Task 1 to be applied successfully, input data must be assembled. The data will be based on a designated load to be served by the wind/PV generation site and for a designated wind farm capacity feeding in to that load. For an associated energy storage facility, the following data is required:

- Daily load curves over a week for a year. If based on the latest available year, this would be sufficient.
- The price of electric energy at bulk delivery levels on an hour-by-hour basis over the same year.
- The expected wind profile over a year at the wind farm and the anticipated power/energy to be generated from it as a function of wind level. This will require coordination with the Resource Advisor who will have access to information on the best locations for wind generation.
- The price of development of the wind farm and the price of the transmission upgrades needed to deliver its energy to the designated load. This will translate into the price of generated energy.
- A selection of energy storage options to study will be made that appear suitable for the task at hand. In addition to hydroelectric generation and pumped storage, these might include superconducting magnetic energy storage (SMES), batteries and regenerative fuel cells. Their capital and operating costs must be acquired.
- Information on any hydroelectric generator that can also supply energy to the same load. The data required from the hydroelectric generator includes its power capacity in MW, its energy that can be delivered over a year in the form of a load duration curve, for heavy, medium and light water years. This information will help determine what capacity is available for contracted energy storage. It is also expected that an energy storage contract will have an associated cost, and estimates of what that cost might be, will be determined.
- Any energy storage facility will have an efficiency value associated with it. There will always be less energy returned than is submitted for storage and this translates into a cost. Estimates for energy storage efficiency for the selected energy storage facilities will be evaluated.

Deliverables:

- 4.3.2a - Energy Storage Evaluation and Development Progress Report

Task 4.3.3: Evaluate Energy Storage Options

The goal of this task is to use the data collected above and evaluate the selected energy storage options for cost effectiveness and their associated ratings, capacity and determine operational improvements of wind generation installations.

The Contractor shall:

- Prepare an Energy Storage Ratings Progress Report. The report shall contain the appropriate ratings for energy storage. In addition, a strategy for the best economic use of the energy storage facility will be proposed along with the benefits that are evident with energy storage.

  Using the model developed in 4.31 and the data acquired in 4.3.2, the various energy storage options will be evaluated. It will be assumed that any new energy storage facility will be located near the designated load, not at the wind farm site. In addition to the wind farm, the energy storage facility can also be used to store and trade energy from the power system when conditions are right. This will have the benefit of contributing to electric energy price stabilization.

  The following quantities will be determined:
    - Rating in MW.
    - Capacity in MWhr
    - Improvement to cost effectiveness of wind energy when the various energy storage options are available.
    - Operating strategy for use of the energy storage facility.

Consideration will also be given to the WAPA Central Valley Project where the hydroelectric resources have potential energy storage capability.

Deliverables:
- 4.3.3a - Energy Storage Ratings Progress Report

Task 4.3.4: Final Project Report
The goal of this task is to prepare a Final Project Report. It will contain recommendations for the feasibility of applying energy storage to enhance the value of renewable energy generated wind farms located near the California – Nevada border.

The Contractor Shall:

- Prepare a Final Report for this project in accordance with the process described in Project 0.6. The report shall include:
  - A recommendation for the best method for energy storage (based on technical, economic and simple environmental evaluations) that can be applied for a wind farm development near the California – Nevada border. In general, specific energy storage facilities are relatively expensive and it may well be that the only economically acceptable application for energy storage is through a contract with one or more hydroelectric generators.
  - Hydroelectric generating companies who are be amenable to a contract for energy storage.
  - Recommended rating and capacity for the energy storage facility if not hydroelectric.
  - Location considerations for energy storage facilities
  - Modeling method and model for evaluating effectiveness of energy storage.
  - A procedure to apply not only to the new wind energy generators, but also to existing installations to improve their effectiveness allowing them to deliver the energy they have generated when it is needed most.

Deliverables:
- 4.3.4a – Final Report Outline for the Energy Storage for Renewable Generation Project
- 4.3.4b - Draft Final Report for the Energy Storage for Renewable Generation Project
- 4.3.4c - Final Project Report for the Energy Storage for Renewable Generation Project

Key Personnel:
None

Key Subcontractors:
Dennis Woodford, Electranix Corporation

EMPHASIS AREA 5:
INTEGRATING PROGRAM FINDINGS TO ENSURE BROAD REPLICABILITY

PROBLEM STATEMENT

Real time integration of technical task work is crucial to maximizing deployment opportunities. Driving renewables into the resource planning decisions of the state's electricity service providers will require ongoing amplification and distribution of the relevant technical findings of PIER projects.

▪**Key Barriers**

Even successful renewable energy research and development initiatives can fail to achieve broad market penetration if sufficient effort is not given to ensuring that program successes are integrated into the ongoing business and resource planning efforts of electricity service providers.

▪**Advancement of Science or Technology**

PPREAT work in this area will expand the total knowledge base about renewable resources as it relates to each of the technologies under evaluation by the group.

EMPHASIS AREA GOALS AND PERFORMANCE OBJECTIVES

- Integrate the resource assessment and project planning elements from the bulk power tasks (wind, solar trough, geothermal) with analysis and conceptual designs associated with the HVDC task.

- Integrate the Distributed Generation Assessment work with distributed generation technology development tasks (Modular Biomass, Stirling engine), including SMUD PIER Project PV Task activities were possible.

- Integrate successes from the total project performance into PPREAT participant renewable energy planning and deployment activities (within a short timeframe from the start of this project).

PROJECT LIST

This emphasis area's work scope involves the following technical projects:

Project 5.1 Technical Project Performance Integration
On an ongoing basis over the life of this project, PPREAT will develop and provide technical integration deliverables aimed at ensuring that the technical findings of this research and development effort are integrated with one another and delivered to PPREAT electricity service providers that can best utilize the work in their ongoing program efforts.

PROJECT 5.1: Technical Project Performance Integration

Project Goals and Objectives

The technical objectives are to: Maximize the value and impacts of the HVDC Intertie assessment by integrating the resource assessment and project planning work in the Bulk Power tasks. There is a large quantity of commercial-quality wind, solar and geothermal resource close to the HVDC line in Oregon, Nevada and California. It is expected that a large (500 MW – 2000 MW) tap will be required to ensure cost effectiveness. Furthermore, it will be critical to have a portfolio of project options to feed into the Line to provide for an optimal loading (mixing the right quantities of wind and solar, which have complimentary seasonal and diurnal production profiles, with some dispatchable geothermal, will be critical to overall economic viability). The integrated output of a multi-component renewable energy mega-project will need to fit into the existing seasonal and daily load on the Line.

The economic/business objectives are to: Feed resource, cost, and other project or technology specific PIER Project results into on-going PPREAT utility resource and project planning activities. PPREAT member PV initiatives, other distributed generation initiatives, and bulk renewable RFP initiatives are underway and are expected to gain momentum throughout the course of this PIER Program. Feeding the economic and business results of this Program directly into the Utility planning and procurement processes will ensure high quality RE implementation.

Prior Research

Advanced Concepts:

While a lot of theoretical analysis has occurred regarding the natural synergies associated with a diverse mix of complimentary renewable resources, this is one of the few instances where those specific characteristics (evening peak for wind, mid-day peak for solar, flat/dispatchable production from geothermal) may be crucial to the overall economic viability of a very large (up to 2 GW) renewable energy resource.

This Program Element will also drive analysis of how bulk power and distributed generation options can be used in complimentary ways to optimize a mix of high-value local generation with remote, low-cost clean supply.

Baseline Conditions

Most experience in California to date with bulk renewable power projects is to plan and operate them on a largely autonomous basis (largely by IPPs). On a limited basis, some projects have been planned on the basis of their fit within an overall utility production portfolio.

Projected Outcomes

Economically-viable HVDC/Bulk Renewables project combination.

Future Years

Work Plan

Task List:

Task 5.1.1 Bulk Renewables – HVDC Integration
Task 5.1.2 Distributed Generation Assessment – Modular Technology Development Integration
Task 5.1.3 Utility Resource Planning Inegration

Task 5.1.1:

The goal of this task is to maximize the value and impacts of the HVDC Intertie assessment by integrating the resource assessment and project planning work in the Bulk Power tasks.

The Contractor shall:

- Establish design criteria for the HVDC interconnect, geothermal resource assessment, wind and solar resource and project planning work as they relate to an integrated project.
- Hold an annual coordination meeting of the 4 Contractors.
- Document results of the cross-cutting analysis of the Bulk Power and HVDC Project Tasks.

Deliverables:

5.1.1a – Bulk Power integration design criteria workshop report

5.1.1b – Bulk Power Integration 1st critical review workshop report
5.1.1c – Bulk Power Integration 2nd critical review workshop report
5.1.1d - Bulk Power Integration – Final results and recommendations report

Task 5.1.2:

- The goal of this task is to integrate the Distributed Generation Assessment work with distributed generation technology development tasks (Modular Biomass, Stirling engine), including SMUD PIER Project PV Task activities were possible.

The Contractor shall:

Feed real-time results from the modular biomass, Stirling engine, and PIER Program PV technology development initiatives into the Distributed Generation Assessment task from this Program, as well as into the on-going distributed generation and PV programs at PPREAT utilities.

Deliverables:
5.1.2a – Distributed Generation Integration – issues workshop report
5.1.2b – Distributed Generation Integration – 1st critical review workshop report
5.1.2c – Distributed Generation Integration – 2nd critical review workshop report
5.1.2d – Distributed Generation Integration – Final results and recommendations report

Task 5.1.3:

- The goal of this task is to drive renewables into the resource planning decisions of the state's electricity service providers will through amplification and distribution of the relevant technical findings of PIER projects.

The Contractor shall:
- Maintain an awareness and understanding of ongoing PPREAT utility generation planning and deployment activities and objectives.
- Hold regular briefings of PIER Program results for utility resource and project planning staff and management.
- Report back on the fit of PIER Program results to the immediate and mid-term challenges for Utility planners, instances where Program results are serving the immediate needs of Utility planning and deployment actions, and where there are gaps that the PIER Program might evolve to fill.

Deliverables:
5.1.3a – Monthly Resource Planning Integration Report

Key Personnel:
None
Key Subcontractors:
Ray Dracker, Research Director, Center for Resource Solutions